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USAAEFA PROJECT NO. 74-34

AIRWORTHINESS AND FLIGHT CHARACTERISTICS EVALUATION YAH-1S IMPROVED COBRA AGILITY AND MANEUVERABILITY HELICOPTER

FINAL REPORT

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Army Aviation Engineering Flight Activity conducted a limited airworthiness and flight characteristics evaluation of the YAH-1S improved Cobra agility and maneuverability helicopter, serial number 70-16055, from 17 March through 17 April 1975. The prototype helicopter, manufactured by Bell Helicopter Company (BHC), Fort Worth, Texas, was tested at Edwards Air Force Base (2302 feet), Bishop (4112 feet), and Coyote Flats (9500 feet), California, a

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Limited flight tests of a prototype aircraft were conducted at 3 test facilities at various altitudes.

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20. Abstract

high-altitude test site located near Bishop. During the evaluation, 40 flights totaling 26 productive flight hours were conducted. Calendar limitations due to required operational testing, coupled with adverse weather conditions, prevented completion of all phases of testing specified in the test plan. Testing was concentrated on hover and level flight performance, controllability, and low-speed flight characteristics at heavy gross weight, high density altitude test conditions. The YAH-1S represents a significant improvement over the AH-1G/Q helicopter by virtue of its increased useful load-carrying capability, directional controllability and control margin, and hover performance capability. The YAH-1S was capable of hovering out of ground effect (OGE) on a European day (2000 feet pressure altitude and 70°F) at its maximum gross weight of 10,000 pounds. On a US Army hot day (95°F), the YAH-1S is capable of hovering OGE at 4000 feet pressure altitude loaded to 9175 pounds. On a standard day at an altitude of 5000 feet, the OGE hover capability of the YAH-1S is increased by approximately 850 pounds in payload over that of the standard AH-1G. The YAH-1S can climb vertically at 300 feet per minute at a gross weight of 9870 pounds on a European day. At 10,000 pounds in the 8-TOW configuration on a European day, the maximum airspeed for level flight for the YAH-1S was approximately 130 knots true airspeed (KTAS), and is determined by the transmission maximum continuous limit. On a standard day at an altitude of 5000 feet, the maximum airspeed for level flight and the specific range of the YAH-1S are comparable to that of the AH-1Q. At no time during the YAH-1S test program was the tail rotor transient torque limit exceeded. Right sideward flight was achieved up to airspeeds of 48 KTAS at a density altitude of 3900 feet and a gross weight of 9060 pounds, and 35 KTAS at a density altitude of 9380 feet and a gross weight of 8820 pounds without loss of directional control. Within the scope of this limited evaluation, the other handling qualities of the YAH-1S are similar to those of the AH-1G/Q. The control system characteristics of the YAH-1S failed to meet several requirements of applicable paragraphs of military specification MIL-H-8501A and the approved BHC deviations to MIL-H-8501A against which they were tested, but were still considered satisfactory. One shortcoming was noted: No reference is made in the AH-1G operator's manual, or the AH-1S supplement to the operator's manual, concerning the usable fuel volume of the crashworthy fuel cell. The usable fuel volume of the crashworthy fuel cell installed in the YAH-1S was measured to be 254 gallons. This shortcoming should be corrected during the next change to the manual.

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INTRODUCTION

BACKGROUND

1. In early 1972, development was initiated for an improved Cobra armament system (ICAS) to upgrade the AH-1G helicopter to meet the requirements for an armed helicopter in a mid- to high-intensity warfare environment. The ICAS helicopter, with a preliminary mockup of the weapons system, designated the AH-1Q, was flight-tested by both the manufacturer, Bell Helicopter Company (BHC), and the United States Army Aviation Systems Test Activity (USAASTA)[1] during the fall of 1972 (ref 1, app A). During April through June 1973, an airworthiness and flight characteristics (A&FC) evaluation was conducted on a prototype model AH-1Q by USAASTA (ref 2). Subsequent analysis of the AH-1Q mission indicated requirements for improved Cobra agility and maneuverability (ICAM). To meet the requirement for ICAM, BHC developed two prototype helicopters designated the YAH-1R and the YAH-1S, differing only in armament configuration. In January 1974, USAAEFA defined test requirements for the ICAM and published the formal test plan for the A&FC evaluation (ref 3). In late January 1975, USAAEFA was directed by the United States Army Aviation Systems Command (AVSCOM) to conduct an Army Preliminary Evaluation (APE) of the YAH-1R and an A&FC evaluation of the YAH-1S helicopters (ref 4). Subsequent to the post testing debriefing, the YAH-1S Program Manager requested that comparisons between the AH-1Q and the YAH-1S be made in this report.

TEST OBJECTIVES

2. The objectives of the YAH-1S A&FC evaluation were as follows:

a. To provide quantitative and qualitative engineering flight test data for determining compliance with the procurement document, airworthiness qualification specification, and applicable paragraphs of military specification MIL-H-8501A (ref 5, app A) and the approved deviations to MIL-H-8501A contained in the AH-1S detail specification (ref 6).

b. To gather data for use in the operator's manual (ref 7) and other handbooks.

c. To identify any deficiencies and shortcomings.

d. To substantiate the safe flight envelope to be released for subsequent Army evaluations and operational use.

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[1] Since redesignated the United States Army Aviation Engineering Flight Activity (USAAEFA).

DESCRIPTION

3. The YAH-1S helicopter is a 10,000-pound attack helicopter derived from the AH-1Q TOW Cobra. This helicopter incorporated some uprated drive system components from the AH-1J SeaCobra helicopter, a BHC Model 212 tail rotor, and the Lycoming T53-L-703 engine with an uninstalled thermal rating of 1800 shaft horsepower (shp) derated to 1290 shp for 30 minutes because of the main transmission limitation. Four wing-mounted external stores locations are provided, two on each side of the fuselage. In addition to the normal Cobra external stores, either one or two TOW missile launchers (two missiles per launcher) can be installed on the two outboard store locations. A detailed description of the AH-1G helicopter and its armament systems is included in the operator's manual. A detailed description of the Model 212 tail rotor is contained in USAASTA Final Report No. 72-30 (ref 8, app A). Appendix B provides a detailed description and photos of the test helicopter (SN 70-16055).

Photo A. YAH-1S Helicopter.

TEST SCOPE

4. The evaluation was conducted on a prototype YAH-1S helicopter at Edwards Air Force Base (2302 feet), Bishop (4112 feet), and Coyote Flats (9500 feet), California, a high-altitude test site located near Bishop. Forty flights totaling 26 productive flight hours were conducted between 17 March and 17 April 1975. The contractor installed and calibrated all instrumentation, installed a USAAEFA-provided airborne data acquisition system, and was responsible for test aircraft maintenance and logistical support during the tests. Flight restrictions and operating limitations were established by the test directive and safety-of-flight release (ref 9, app A) issued by AVSCOM, in accordance with the proposed YAH-1S supplement to the operator's manual (ref 10). Primary emphasis was directed toward aircraft performance and high-altitude in-ground-effect (IGE) handling qualities. Stringent calendar limitations, coupled with adverse weather conditions, prevented completion of all phases of testing as specified in the test plan. Except where noted, the evaluation was conducted with the stability and control augmentation system (SCAS) ON. Aircraft configurations tested included clean (no wing-mounted external stores) and 8-TOW (two dual-TOW launchers on each outboard wing store location). Flight test conditions are shown in table 1.

TEST METHODOLOGY

5. Engineering flight test techniques described in references 11 through 13, appendix A, were used in conducting tethered hover, level flight performance, and selected handling qualities tests. Test methods for the handling qualities tests are briefly described in the applicable sections of this report, and more extensively in appendix D. Data were recorded on magnetic tape. Hand-recorded cockpit data were taken from sensitive cockpit indicators to facilitate correlation of the magnetic tape-recorded data. A detailed listing of the test instrumentation is contained in appendix C. Airspeeds for forward, rearward, and sideward low-speed flight (less than 50 knots true airspeed (KTAS)) were determined by a calibrated pace vehicle. Performance calculations were based on power available and fuel flow obtained from the proposed supplement to the AH-1G operator's manual. Lycoming Model Specification 104.43 for the T53-L-703 engine was used as a basis for developing the AH-1S supplement to the operator's manual. Data reduction techniques are further described in appendix D. Data reduction was accomplished using the USAAEFA computer facilities. The Handling Qualities Rating Scale (HQRS) used to augment pilot comments relative to handling qualities is presented in appendix D.

Table 1. Flight Test Conditions.[1]

Test	Average Gross Weight (lb)	Average Density Altitude (ft)	True Airspeed (kt)
Hover performance[2]	8400 to [3]11,300	1100 and 9300	Zero
Level flight performance	8400 to 9700	5400 to 10,800	39 to 145
Control positions in trimmed forward flight	8100	5600	[4]42 to 128
	9600	11,000	[4]33 to 91
Controllability[5]	8800	9600	Zero
	8600	10,400	37 (rearward)
	8800	9900	37 to 90-degree azimuth[6]
	8700	10,100	37 to 75-degree azimuth[6]
Low-speed flight	8900	4300	Zero to 50
	8900	9400	Zero to 35

[1]8-TOW external stores configuration.
Longitudinal cg: 192.5 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
[2]Clean configuration.
5-feet IGE and OGE skid heights.
Rotor speed range from 294 to 324 rpm.
[3]Gross weight plus cable tension.
[4]Calibrated airspeed.
[5]SCAS ON and OFF.
[6]Direction of flight measured clockwise from nose of aircraft.

RESULTS AND DISCUSSION

GENERAL

6. An A&FC evaluation of the YAH-1S helicopter was performed to determine the effect of power train and directional control modifications and increased gross weight on the performance and handling qualities of the basic AH-1G/Q airframe and rotor system. Primary emphasis was placed on hover and level flight performance, controllability, and low-speed flight characteristics at heavy gross weight, high density altitude test conditions. The YAH-1S represents a significant improvement over the AH-1G/Q helicopter by virtue of its increased useful load-carrying capability, directional controllability and control margin, and hover performance capability. One shortcoming was noted: No reference is made in the AH-1G operator's manual or the AH-1S supplement to the operator's manual concerning the usable fuel volume of the crashworthy fuel cell. This shortcoming should be corrected during the next change to the manual.

PERFORMANCE

General

7. Hover performance and level flight performance testing was conducted on the YAH-1S helicopter and the results compared to the AH-1Q helicopter where applicable. The YAH-1S can hover out of ground effect (OGE) on a standard day at an altitude of 5000 feet and a gross weight of 10,000 pounds, a substantial improvement over the AH-1Q. On a standard day at an altitude of 5000 feet, the maximum level flight airspeed and specific range of the YAH-1S is comparable to that of the AH-1Q. There was one shortcoming noted: The usable fuel volume of the crashworthy fuel cell installed in the YAH-1S is not referenced in the AH-1G operator's manual or in the proposed supplement.

Hover Performance

8. Hover performance testing was conducted IGE at a 5-foot skid height and OGE at a 100-foot skid height at the conditions shown in table 1. The tethered hover technique was used to obtain a majority of the hover performance data and is described in appendix D. A limited amount of free flight hovering was accomplished to verify the tethered hover results. A summary of IGE and OGE hover performance is shown in figures 1 and 2, appendix E. Nondimensional hover performance data are presented in figures 3 and 4.

9. Hover capability for a standard day, an ambient temperature of 70°F at all altitudes, and a hot day (95°F at all altitudes) was determined from figures 3 through 5, appendix E. On a European day, defined as 2000 feet pressure altitude and 70°F, the YAH-1S can hover at the maximum gross weight of 10,000 pounds

both IGE and OGE. On a US Army hot day of 95°F and 4000 feet pressure altitude, the YAH-1S can hover at a skid height of 5 feet IGE at its maximum gross weight; however, the gross weight must be reduced to 9175 pounds to hover OGE. Hover performance of the AH-1Q is similar to that of the AH-1G with a Model 801 tail rotor installed. Comparison of the YAH-1S to the AH-1G/801 for a standard day is shown in figure A. The OGE hover performance of the YAH-1S compared to the AH-1G/801 indicates a net increase in payload from 880 to 1190 pounds for the conditions shown at altitudes where maximum power is required. Similarly, the IGE 5-foot skid height hover performance of the two aircraft shows an increase in net payload for the YAH-1S from 690 to 900 pounds.

10. To satisfy the directional control requirement intent of MIL-H-8501A, a minimum of 10 percent of full directional control remaining has been established as a limit. This directional control requirement limits standard-day 5-foot skid height hovering performance of both the AH-1G/801 and the YAH-1S helicopters, as shown in figure A. This reduction in hover capability at a 5-foot skid height extends to nearly 700 pounds for the AH-1G/801, while only half that much or 360 pounds for the YAH-1S for the conditions shown. The difference in gross weight for OGE hover performance when limited by the requirement for 10-percent directional control margin remaining ranged to slightly over 200 pounds for the AH-1G/801, whereas the YAH-1S OGE hover capability was not limited by this directional control requirement.

Vertical Climb Performance

11. Vertical climb performance was calculated using the results of the OGE hover performance tests (fig. 4, app E) and the power available supplied by the engine model specification (fig. 5), as presented in the YAH-1S supplement to the operator's manual. The method used employs the momentum theory adjusted for climb power corrections, as described in USAASTA Final Report No. 68-55 (ref 14, app A) and summarized in appendix D. The results of these calculations are presented in figure 6, appendix E. On a European day the YAH-1S can climb at 175 feet per minute (ft/min) at a gross weight of 10,000 pounds, the maximum gross weight of the aircraft. The gross weight must be reduced to 9870 pounds to achieve a climb rate of 300 ft/min on a European day. On a hot day (95°F) at a pressure altitude of 4000 feet, the aircraft can climb at 300 ft/min at a gross weight of 8900 pounds. A climb rate of 300 ft/min was identified in reference 15, appendix A.

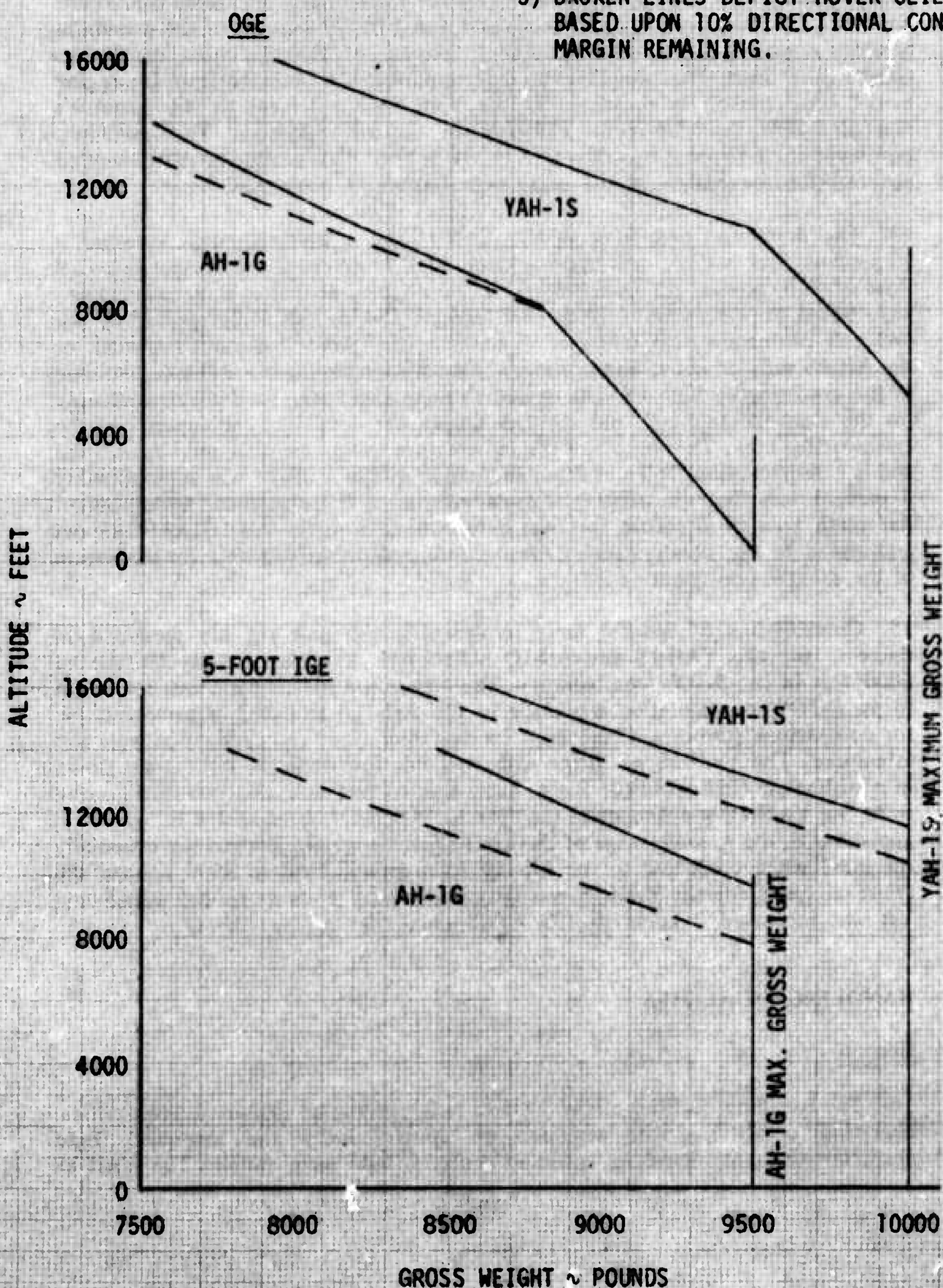
Level Flight Performance

12. Level flight performance tests were conducted to determine power required and fuel flow as a function of airspeed at the conditions listed in table 1. Data were obtained in stabilized level flight, at zero sideslip, and at incremental airspeeds from 30 KTAS to the maximum airspeed for level flight for the available power (V_H). The technique utilized is described in appendix D. The results of these tests are presented nondimensionally in figures 7 through 9, and dimensionally in figures 10 through 13, appendix E.

FIGURE A. HOVER CAPABILITY COMPARISON

STANDARD DAY

NOTES: 1) AH-1G REPRESENTED UTILIZES MODEL 801 TRACTOR TAIL ROTOR.
2) SOLID LINES DEPICT HOVER CEILING BASED UPON MILITARY POWER AVAILABLE.
3) BROKEN LINES DEPICT HOVER CEILING BASED UPON 10% DIRECTIONAL CONTROL MARGIN REMAINING.



13. The level flight performance of the YAH-1S at the maximum gross weight of 10,000 pounds in the 8-TOW configuration at a forward cg on a European day is presented in figure B. The V_H for the YAH-1S at these conditions was approximately 130 KTAS, as determined by the transmission maximum continuous limit of 1134 shp. The cruise airspeed, as defined by 99 percent of the maximum specific range, was determined to be in excess of the maximum continuous transmission limit. Fuel flow for this determination was obtained from the engine model specification as presented in the YAH-1S supplement to the operator's manual with the 5-percent conservatism factor removed. The minimum power-required airspeed was shown to be 64 KTAS. This is also the recommended airspeed for maximum rate of climb and maximum endurance.

14. The maximum endurance of the YAH-1S on a European day, assuming a 10-percent fuel reserve, was approximately 2.9 hours with a corresponding fuel flow of 510 pounds per hour (lb/hr). It should be noted that these calculations were based on a maximum usable fuel load of 254 gallons as determined by the fuel cell calibration. No reference is made in the AH-1G operator's manual, or the AH-1S supplement to the operator's manual, concerning the usable fuel volume of the crashworthy fuel cell. The operator's manual contains such information only for the standard fuel cell, and specifies simply the total fuel cell capacity of the crashworthy tank. The absence of this information in the manual should be rectified and is a shortcoming. The maximum endurance of the YAH-1S was approximately 3 percent less than the AH-1Q at gross weights of 9500 pounds. An equivalent flat plate area of 6 square feet was determined from the AH-1Q A&FC report and added to the nondimensional clean configuration AH-1Q data for simulation of an 8-TOW configuration.

15. Comparisons of specific range, cruise airspeed, and V_H are presented in figure C for the YAH-1S and AH-1Q helicopters at a standard-day altitude of 5000 feet in the 8-TOW configuration. The correction for flat plate area equivalent to an 8-TOW configuration was made to the AH-1Q, as stated in paragraph 14, for comparison purposes. Corrections for test technique and cg location were not attempted. The YAH-1S was flown with zero sideslip, while the AH-1Q was flown in coordinated (ball-centered) flight. According to test data, and fuel flow derived from the YAH-1S supplement to the operator's manual, as presented in figure 14, appendix E, the specific range of the YAH-1S at the cruise airspeed was essentially the same when compared to the AH-1Q. At a gross weight of 9500 pounds, the cruise airspeed for the YAH-1S was increased nearly 5 knots to 129 KTAS and V_H was increased 2 knots to 133 KTAS over that of the AH-1Q.

HANDLING QUALITIES

General

16. The handling qualities of the YAH-1S helicopter were evaluated under critical operating conditions with emphasis on controllability and low-speed flight characteristics. No handling qualities shortcomings were noted. The YAH-1S

FIGURE 8. LEVEL FLIGHT PERFORMANCE
YAH-1S USA S/N 70-16055

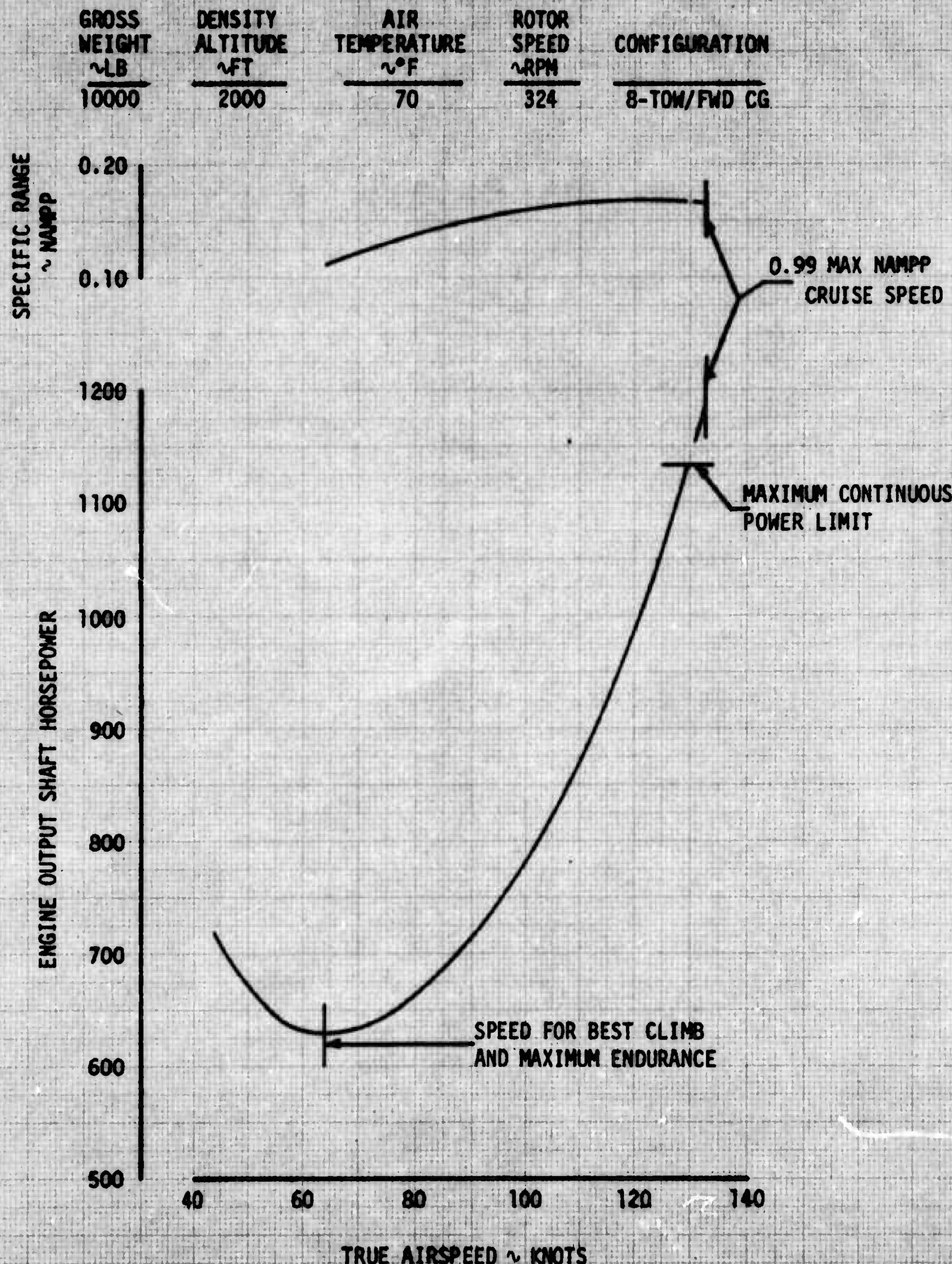
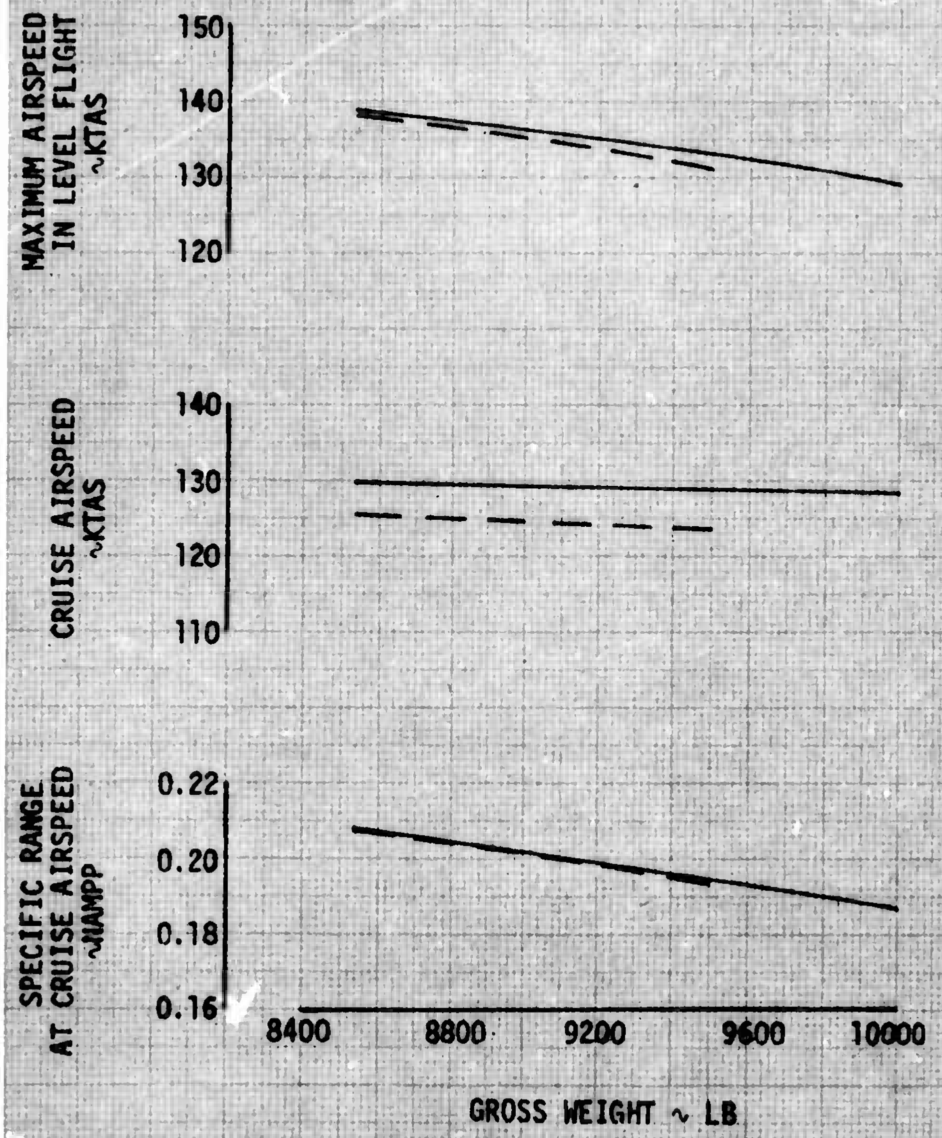


FIGURE C. LEVEL FLIGHT PERFORMANCE COMPARISON

STANDARD DAY - 5000 FEET
ROTOR SPEED = 324 RPM
8-TOW CONFIGURATION

SYMBOL	AIRCRAFT TYPE	FLIGHT CONDITION	CG LOCATION ~IN.
———	YAH-1S	0° SIDESLIP	192.4 (FWD)
- - -	AH-1G	BALL CENTERED	194.6 (MID)



represents a significant improvement in directional controllability and directional control margin over the AH-1G/Q helicopter during low-speed flight at high gross weights and high density altitudes. At no time during the YAH-1S test program was the tail rotor transient torque limit exceeded. Right sideward flight was achieved up to airspeeds of 48 KTAS at a density altitude of 3900 feet and a gross weight of 9060 pounds, and 35 KTAS at a density altitude of 9380 feet and a gross weight of 8820 pounds without loss of directional control. Within the limited scope of this evaluation, the other handling qualities of the YAH-1S were very similar to those of the AH-1G/Q. The control system characteristics of the YAH-1S failed to meet several requirements of applicable paragraphs of MIL-H-8501A and the approved BHC deviations to MIL-H-8501A against which they were tested, but were not considered unsatisfactory.

Control System Characteristics

17. The flight control system characteristics were evaluated on the ground with the engine and rotor stopped, and electrical and hydraulic power furnished by external sources, utilizing the technique described in appendix D. Control forces were measured on the pilot and copilot/gunner controls with the force trim ON and SCAS OFF. The variation of cyclic control force with control position at the pilot station was essentially linear. The control system characteristics are presented in figures 15 through 18, appendix E, and are summarized in table 2. Within the scope of this test, the control system characteristics of the YAH-1S helicopter were determined to be essentially the same as a production AH-1G; they failed to meet the applicable requirements of paragraphs 3.2.7, 3.3.13, 3.4.2, 3.2.4, 3.3.11, 3.2.6, and 3.3.12 of MIL-H-8501A, and the approved contractual deviations of MIL-H-8501A; however, the control force characteristics are satisfactory for the attack helicopter mission.

Control Positions in Trimmed Forward Flight

18. Control positions in trimmed forward flight were determined during the level flight performance tests at the conditions listed in table 1, using the technique described in appendix D. The data are presented in figure 19, appendix E. The variation of longitudinal stick position with airspeed was essentially linear, requiring increasing forward cyclic with increased airspeed. The variation of lateral control position with airspeed was nonlinear; cyclic position moved right with increasing airspeed to approximately 80 knots calibrated airspeed (KCAS), and then moved back to the left as airspeed approached 130 KCAS. This reversal was discernible, but not objectionable, to the pilot. The variation of directional control position with airspeed was similar to that of the lateral cyclic; however, this movement was not discernible to the pilot. The total variation of lateral cyclic and directional control was less than 0.75 inch throughout the airspeed range tested. A comparison of the YAH-1S and the AH-1Q control positions in trimmed forward flight is presented in figure D. The YAH-1S required approximately 10 percent less left directional control when compared to the AH-1Q. Within the scope of this test, the control position characteristics of the YAH-1S in trimmed forward flight are satisfactory for the attack helicopter mission, and met the applicable requirements of MIL-H-8501A.

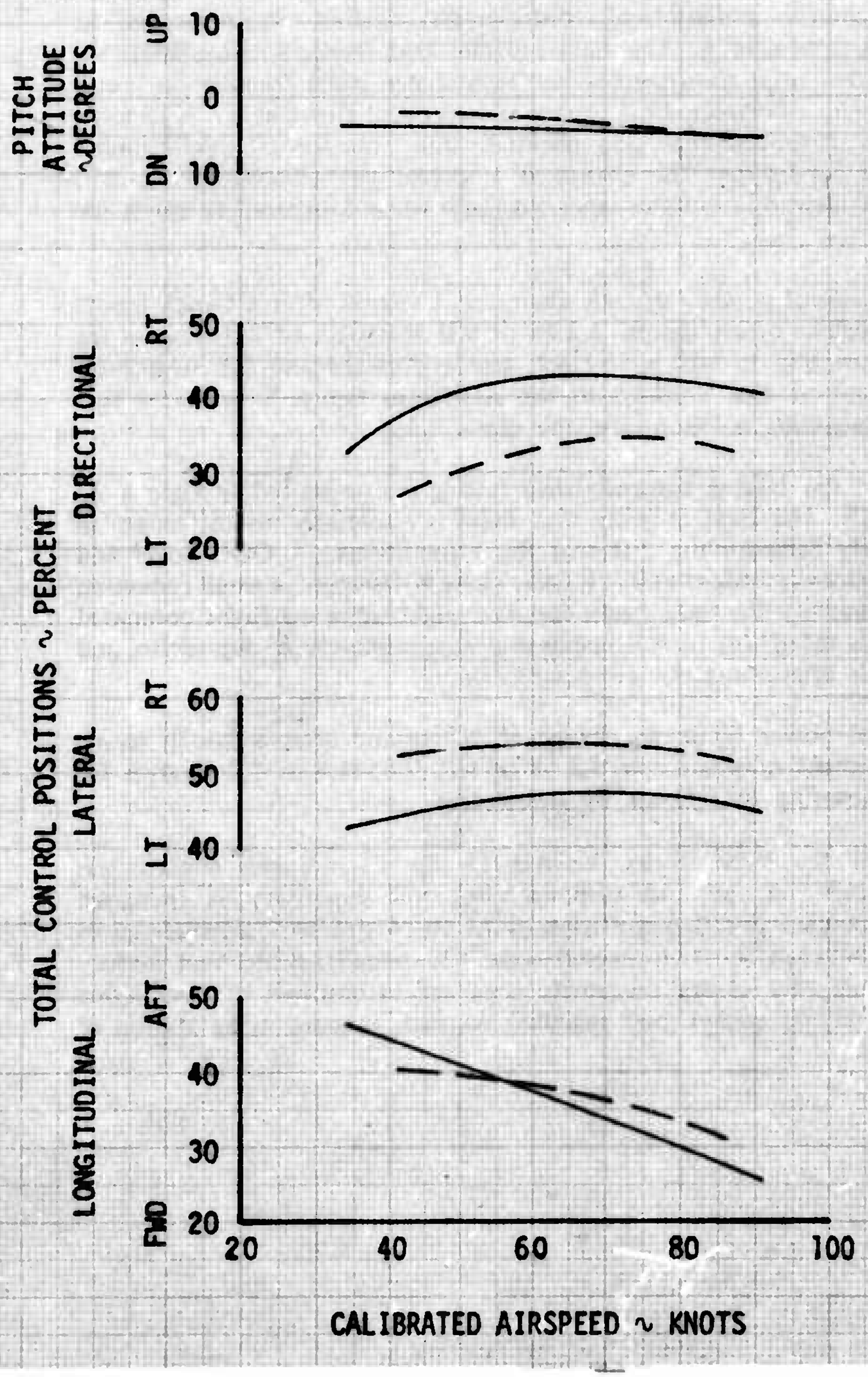
Table 2. Control System Characteristics.[1]

Control	Direction	Breakout Force (Including Friction) (lb)			Control Force Versus Position Gradient (lb/in.)			Limit Control Force (lb)		
		Test Results		MIL-H-8501A Maximum (Deviation[3])	Test Results		MIL-H-8501A Maximum	Test Results		MIL-H-8501A Maximum
		Pilot	Gunner[2]		Pilot	Gunner[2]		Pilot	Gunner[2]	
Longitudinal	Forward	3.0	5.0	1.5 (2.25)	1.7	4.5	2	13.0	30.0	8
	Aft		7.0							
Lateral	Left	3.5	5.0	1.5 (2.25)	1.0	3.5	2	10.5	22.0	7
	Right	2.0	3.0							
Directional	Left	3.0	3.0	7	10.0	10.0	NA	40.0	40.0	15
	Right	4.0	4.0					45.0	45.0	
Collective	Up[4]	4.0	5.0	3	NA	NA	NA	9.0	11.0	7
	Down[5]	9.0	10.0						10.0	

[1]Force trim ON.
Control force measured at center of grip and pedal.
Cyclic friction at manufacturer's preset value.
[2]Side-arm controller.
[3]Pilot cyclic.
[4]Initiated from full-down stop.
[5]Initiated from full-up stop.

FIGURE D. CONTROL POSITIONS COMPARISON IN TRIMMED FORWARD FLIGHT

SYMBOL	AIRCRAFT TYPE	CONFIGURATION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG C_T
———	YAH-1S	8-TOW	9460	192.9(FWD)	10960	0.006518
— —	AH-1Q	8-TOW,2-M159C	9140	195.9(MID)	11920	0.006530



Controllability

19. Controllability characteristics were evaluated in hover, rearward, and sideward flight at the test conditions listed in table 1. Test techniques are described in appendix D. There were no objectionable delays in the development of angular rates in response to control displacement. Aircraft responses were essentially uncoupled for cyclic control inputs. Pedal control inputs resulted in a slight right roll with right yaw, which was damped as the yaw rate began, causing no noticeable controllability problems.

20. The results of the longitudinal controllability testing are presented in figures 20 and 21, appendix E. The data indicate that there is little difference in magnitude, control response (degrees per second per inch) (deg/sec/in.), and sensitivity (deg/sec^2/in.) between OGE hover and rearward flight at 37 KTAS for the YAH-1S. Pitch attitude change was essentially the same for aft cyclic inputs for all tested flight conditions. The change at 1 second was reduced by one-half, or 1.5 degrees, for forward inputs in rearward flight when compared to hover for a 1-inch input.

21. Longitudinal control power (attitude change at 1 second after a 1-inch input) exceeds the requirement of paragraph 3.2.13 of MIL-H-8501A of 2.0 degrees for the YAH-1S for hovering in still air by 1.1 degrees forward and 0.8 degree aft of trim. Comparison of the YAH-1S to the AH-1Q in figure E indicates that longitudinal controllability is essentially the same.

22. The results of the lateral controllability testing are presented in figures 22 and 23, appendix E. The data indicate that there is essentially no difference in lateral controllability between the different flight conditions, *ie*, OGE hover and rearward and right sideward flight at 37 KTAS. There is, however, a small reduction in response and sensitivity for right cyclic inputs in right sideward flight compared to OGE hover. This reduction in roll response is approximately 8 deg/sec/in. and in roll sensitivity is approximately 13 deg/sec^2/in.

23. Lateral control power (attitude change at 1/2 second after a 1-inch input) exceeds the requirement of paragraph 3.3.18 of MIL-H-8501A of 1.2 degrees for the YAH-1S for hovering in still air by 0.9 degree.

24. Comparison of the YAH-1S to the AH-1Q (fig. F) indicates slightly less magnitude in attitude change and response, but roll sensitivity is increased approximately 50 percent in either direction or 13 to 14 deg/sec^2/in. Differences in test conditions between the two aircraft were 420 pounds, 8200 feet density altitude, forward and mid center of gravity (cg), and in moment of inertia due to the additional M159C rocket pod installed on each inboard wing station of the AH-1Q.

FIGURE E. LONGITUDINAL CONTROLLABILITY COMPARISON

SYMBOL	AIRCRAFT TYPE	CONFIGURATION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG C_T
———	YAH-1S	8-TOW	8800	192.2 (FWD)	9600	0.005845
- - -	AH-1Q	8-TOW,2-M159C	9180	195.8 (MID)	1500	0.004764

NOTE: SCAS ON.

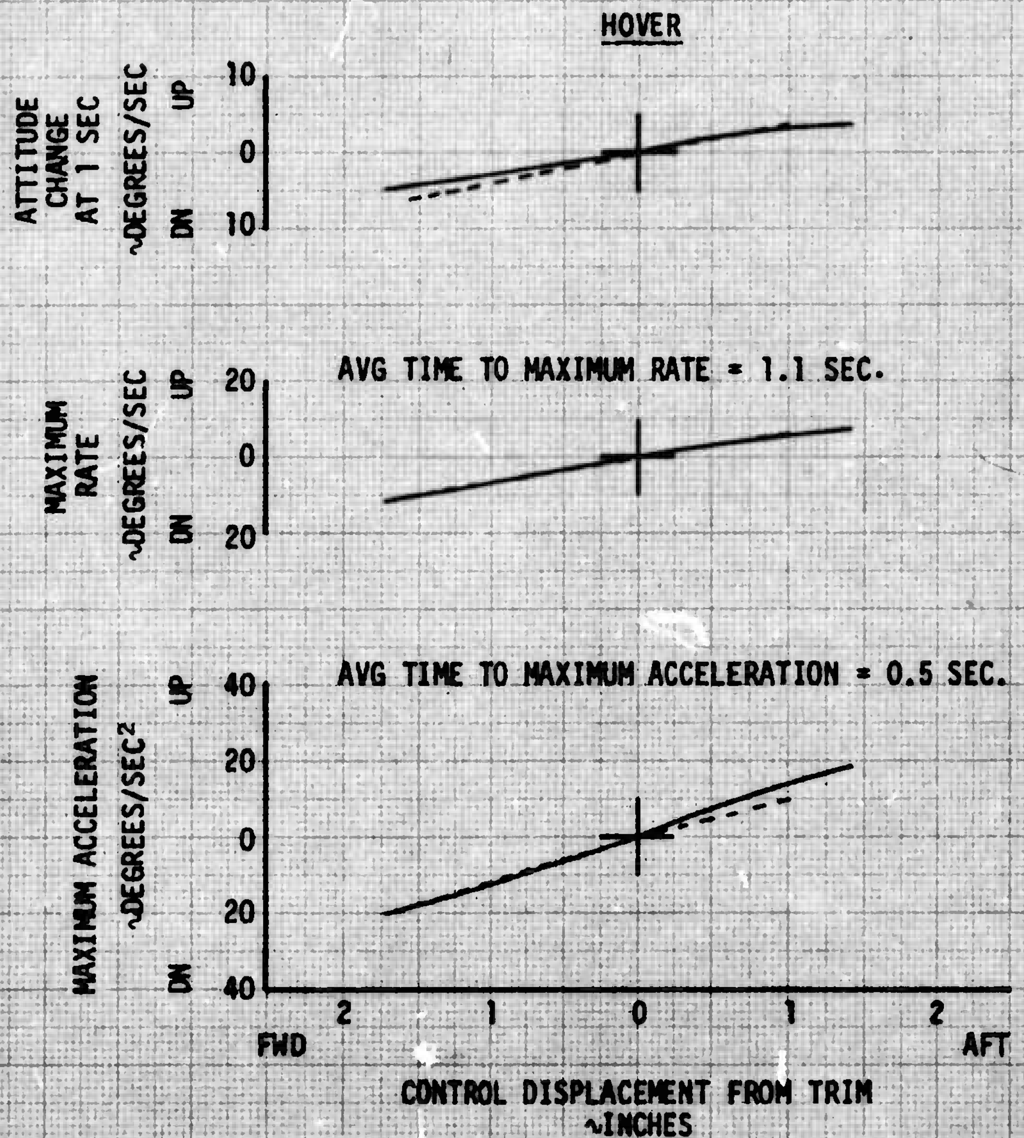
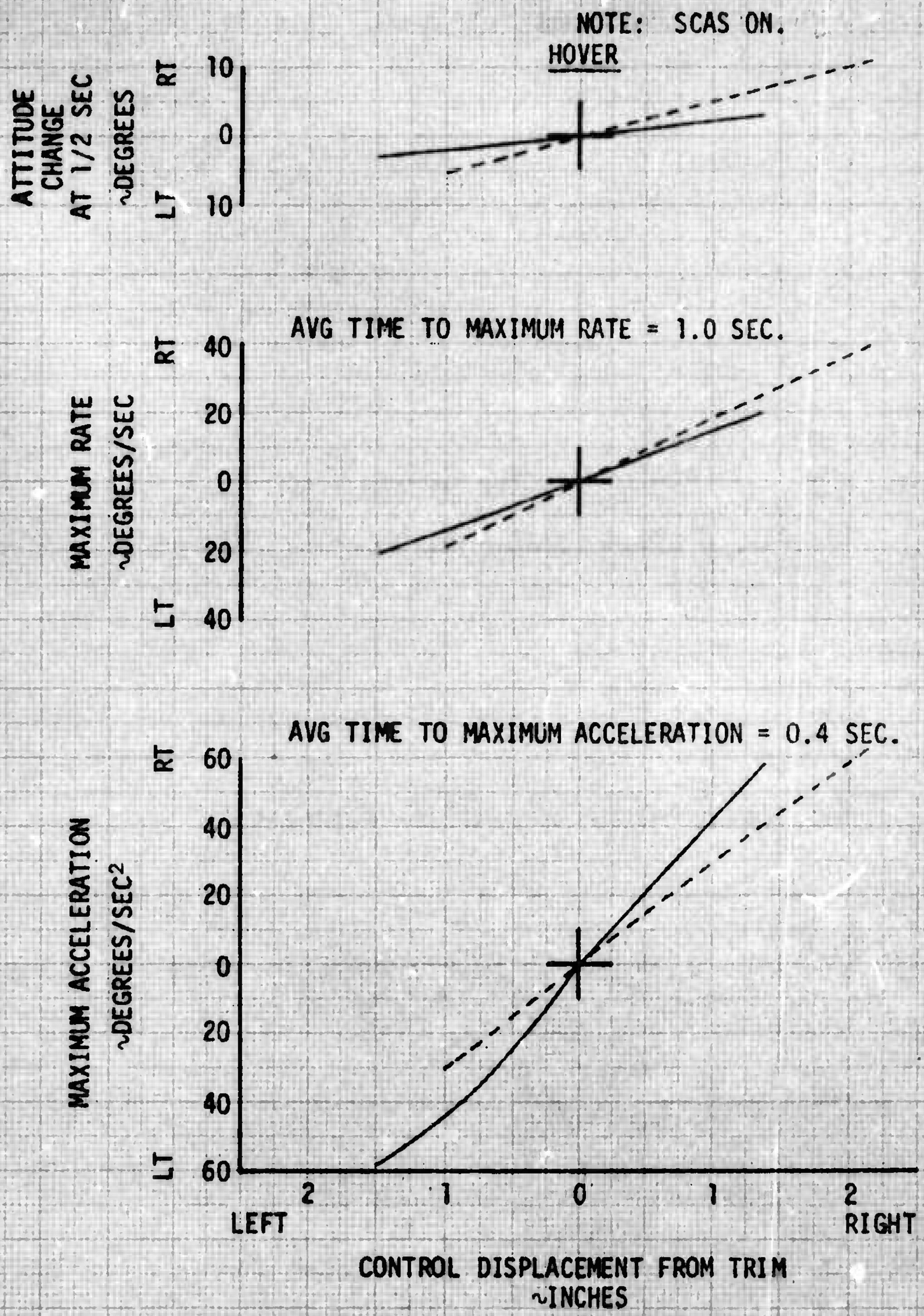


FIGURE F. LATERAL CONTROLLABILITY COMPARISON

SYMBOL	AIRCRAFT TYPE	CONFIGURATION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG C_T
———	YAH-1S	8-TOW	8760	192.2 (FWD)	9700	0.005836
- - -	AH-1Q	8-TOW,2-M159C	9180	195.8 (MID)	1500	0.004764



25. The results of the directional controllability testing are presented in figures 24 and 25, appendix E. Controllability is similar for 10-foot IGE hover and OGE hover. Yaw attitude change and response is slightly reduced for flight at 37 KTAS at an azimuth heading of 75 degrees clockwise from the nose of the aircraft. Comparison of 1-inch right directional inputs between 75 degrees azimuth flight and hover indicates a reduction of 2.3 degrees in attitude change at 1 second.

26. Directional control power (attitude change at 1 second after a 1-inch input) exceeds the requirement of paragraph 3.3.5 of MIL-H-8501A of 5.0 degrees for the YAH-1S, while hovering in still air, by 3.2 degrees left of trim and 7.0 degrees right of trim. Directional control power failed to meet the requirement of paragraph 3.3.6 of MIL-H-8501A for hovering in a 35-knot wind at the critical azimuth. Applying remaining left directional pedal in 75-degree azimuth flight at 37 KTAS produced a yaw attitude change of 2.5 degrees, which is 2.5 degrees less than the required 5.0 degrees. The data indicate that for the critical azimuth of 90 degrees at similar test conditions, 0.25 inch of directional control remains at 35 KTAS. This amount of pedal displacement yields 2.1 degrees of yaw attitude change, thereby failing to meet the requirements of MIL-H-8501A by 2.9 degrees.

27. Comparison of the YAH-1S to the AH-1Q in figure G indicates similar yaw sensitivity and response, but attitude change after 1 second is decreased approximately 40 percent, or 3.2 degrees for a 1/2-inch left input. A slight decrease in the same parameter exists to the right. These comparisons were made from different test conditions, as the YAH-1S was 460 pounds lighter and approximately 8100 feet higher in density altitude than the AH-1Q, the longitudinal cg was forward for the YAH-1S and mid for the AH-1Q, and due to two M159C rocket pods installed on the inboard wing stations of the AH-1Q, the moment of inertia was greater than that for the YAH-1S. At no time during the controllability testing was the tail rotor transient torque limit reached. Within the scope of this test, controllability characteristics of the YAH-1S in a hover are satisfactory for the attack helicopter mission.

Low-Speed Flight Characteristics

28. The handling qualities of the YAH-1S helicopter during low-speed translational flight were evaluated at the test conditions listed in table 1, using the test techniques described in appendix D. Low-speed flight test results are presented in figures 26 through 45, appendix E.

29. Comparison of the YAH-1S to the AH-1G with a Model 801 tail rotor installed (similar to the AH-1Q) for right sideward flight is shown in figure H. At an average gross weight of 9100 pounds and an average density altitude of 3740 feet, the YAH-1S helicopter was flown to an airspeed of 48 KTAS without contacting the left directional control stop. The AH-1G/801, at an average gross weight of 8860 pounds and an average density altitude of 6000 feet, required considerably more left pedal and consequently could not achieve 30 KTAS before contacting the directional control stop. The 10-percent directional control margin was reached

FIGURE G. DIRECTIONAL CONTROLLABILITY COMPARISON

SYMBOL	AIRCRAFT TYPE	CONFIGURATION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG C_T
——	YAH-1S	8-TOW	8720	192.2 (FWD)	9600	0.005756
- - -	AH-1Q	8-TOW,2-M159C	9180	195.8 (MID)	1500	0.004764

NOTE: SCAS ON.

HOVER

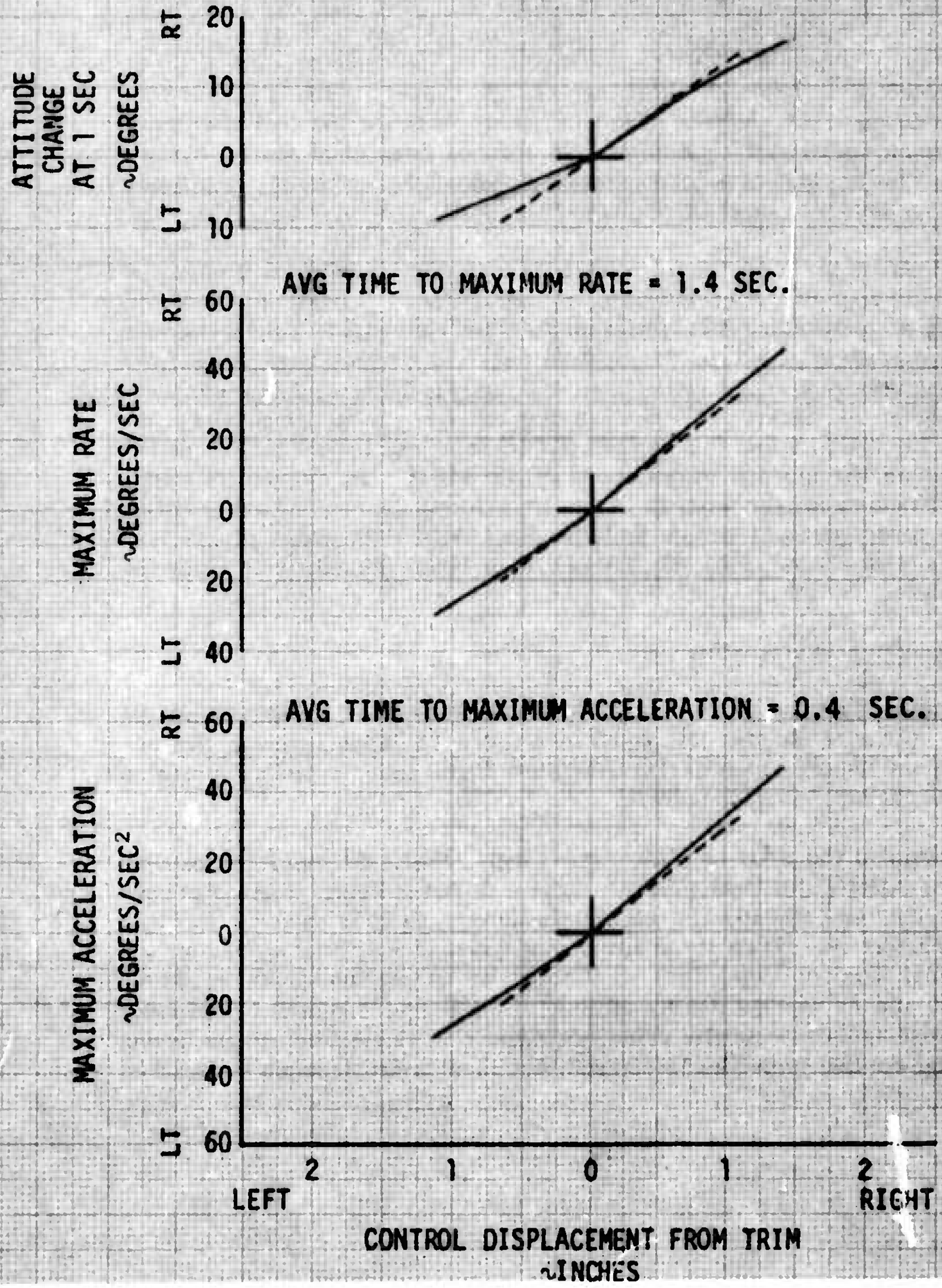
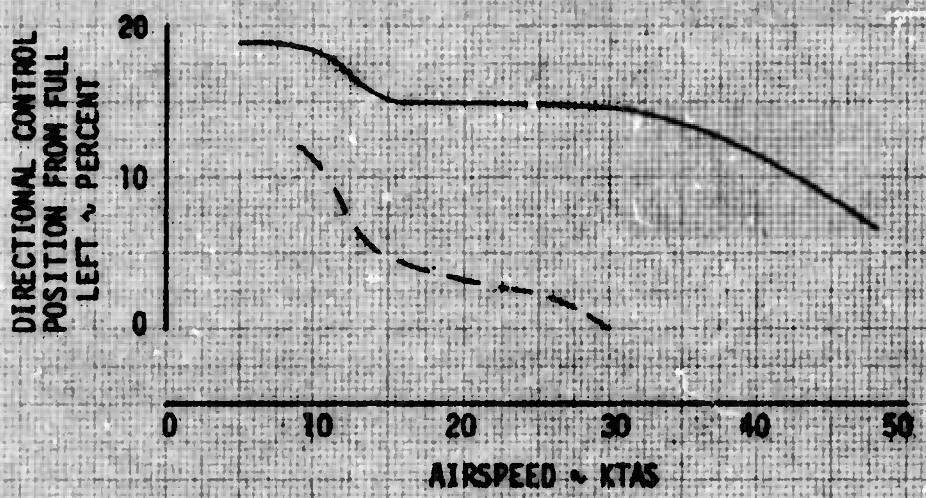


FIGURE H. DIRECTIONAL CONTROL COMPARISON IN RIGHT SIDEWARD FLIGHT

SYMBOL	AIRCRAFT TYPE	CONFIGURATION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG C_T
———	YAH-1S	8-TOW	9100	192.7 (FWD)	3740	0.005049
– – –	AH-1G/801	4-M159C	8860	194.0 (FWD)	6000	0.005264



at 11 KTAS for the AH-1G/801, while the YAH-1S reached approximately 43 KTAS before encountering this restriction. Data indicate that the tail rotor shp maximum continuous torque limit was not reached during testing at these conditions. Extrapolated test data show that this torque limit would be reached at approximately 50 KTAS.

30. Figure 26, appendix E, is a summary of low-speed flight. This shows the maximum airspeeds obtainable while maintaining a 10-percent directional control margin. Right sideward flight airspeeds in excess of 42 KTAS were experienced by the YAH-1S at approximately 8980 pounds gross weight and 4300 feet density altitude before the 10-percent left directional control margin was reached. At 8900 pounds and 9440 feet density altitude, the aircraft could achieve approximately 10 KTAS in right sideward flight before reaching the 10-percent left directional control margin.

31. The YAH-1S directional control margin is a substantial improvement over that of the AH-1G. The critical azimuth for the YAH-1S is approximately a 90-degree right crosswind. Transient values of control position were such that the aircraft could be flown to 50 KTAS under the conditions stated in figure 36, appendix E, and up to at least 35 KTAS (the maximum capability of the pace vehicle) under the conditions stated on figure 43. Airspeeds between 15 and 30 KTAS at the 75-degree wind azimuth were the most critical from an aircraft control standpoint; however, the YAH-1S was flown through this critical regime with minimal pilot compensation (HQRS 3). At no time during any low-speed flight testing was the tail rotor torque transient limit reached. Within the scope of this test, the handling qualities of the YAH-1S in low-speed flight simulating a hover in varying wind conditions are satisfactory for the attack helicopter mission.

STRUCTURAL DYNAMICS

Vibration

32. A vibration survey was taken on all flights. Twelve sensors were located on the aircraft. Summaries of amplitudes at various main rotor blade harmonic frequencies are shown for six static and dynamic maneuvers in tables 1 through 12, appendix E. No maneuvers were performed specifically to induce high vibrations.

33. The pilot and crew experienced no vibration levels which impaired performance or comfort. At no time did the amplitudes exceed the maximums specified in MIL-H-8501A.

Structural Loads

34. Main and tail rotor pitch link loads were recorded in conjunction with the performance and handling qualities testing. The results for seven representative static and dynamic maneuvers are summarized in tables 13 and 14, appendix E.

35. The tail rotor pitch link loads did not exceed the limits established by the safety-of-flight release. Overall, the YAH-1S exhibited slightly greater tail rotor pitch link loads than those of the AH-1G with the Model 801 tail rotor (ref 16, app A).

CONCLUSIONS

GENERAL

36. Within the scope of this test, the YAH-1S helicopter represents a significant improvement over the AH-1G/Q helicopter by virtue of its increased useful load carrying, directional control, and hover performance capabilities. One shortcoming was identified.

SHORTCOMING

37. No reference is made in the AH-1G operator's manual, or the AH-1S supplement to the operator's manual, concerning the usable fuel volume of the crashworthy fuel cell (para 14).

SPECIFICATION COMPLIANCE

38. The handling qualities of the YAH-1S helicopter met all applicable requirements of MIL-H-8501A, with approved deviations to MIL-H-8501A of the BHC detail specification against which they were tested, except as listed below.

a. Paragraphs 3.2.7, 3.3.13, and 3.4.2 - All breakout forces (including friction), except directional, were greater than allowed (para 17).

b. Paragraph 3.2.4 - The longitudinal force required to move the copilot/gunner stick 1 inch from trim was 4.5 pounds forward and aft, 2.5 pounds (125 percent) greater than allowed (para 17).

c. Paragraph 3.3.11 - The lateral force required to move the copilot/gunner stick 1 inch from trim was 3.5 pounds left and right, 1.5 pounds (75 percent) greater than allowed (para 17).

d. Paragraphs 3.2.6, 3.3.12, and 3.4.2 - The limit control forces are greater than allowed (para 17).

e. Paragraph 3.3.6 - Inadequate control margin remained at the critical azimuth to produce the yaw displacement required in the first second after rapid application of full directional control in the critical direction (para 26).

RECOMMENDATION

39. Correct the shortcoming identified in paragraph 14 during the next change to the operator's manual.

APPENDIX A. REFERENCES

1. Final Report, USAASTA, Project No. 72-18, *Army Preliminary Evaluation, Improved Cobra Armament System*, December 1972.

2. Final Report, USAASTA, Project No. 72-43, *Airworthiness and Flight Characteristics Evaluation, AH-1Q Helicopter*, July 1973.

3. Test Plan, USAAEFA, Project No. 74-34, *Airworthiness and Flight Characteristics Evaluation, YAH-1S Improved Cobra Agility and Maneuverability Helicopter*, February 1975.

4. Letter, AVSCOM, AMSAV-EFT, 22 January 1975, subject: AVSCOM Test Directive No. 74-34, Airworthiness and Flight Characteristics Evaluation of the YAH-1S ICAM Helicopter.

5. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities; General Requirements For*, 7 September 1961, with Amendment 1, 3 April 1962.

6. Detail Specification, Bell Helicopter Company, No. 209-947-265, "Detail Specification for Model AH-1S Helicopter; Appendix II, Deviations to MIL-H-8501A," 13 August 1975.

7. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter*, 19 June 1971.

8. Final Report, USAASTA, Project No. 72-30, *Engineering Flight Test, AH-1G Helicopter with Model 212 Tail Rotor, Part II, Performance and Handling Qualities*, September 1973.

9. Letter, AVSCOM, AMSAV-EQI, 17 March 1975, subject: Safety of Flight Release for USAAVSCOM/USAAEFA Project No. 74-34.

10. Technical Manual, TM 55-1520-221-10, *YAH-1S Proposed Supplement to the Operator's Manual, Army Model AH-1G Helicopter*, 15 February 1975.

11. Pamphlet, Army Materiel Command, AMCP 706-204, *Engineering Design Handbook, Helicopter Performance Testing*, 1 August 1974.

12. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control*, 10 June 1968.

13. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance*, 28 June 1968.

14. Final Report, USAASTA, Project No. 68-55, *Flight Evaluation, Compliance Test Techniques for Army Hot Day Hover Criteria*, April 1974.

15. Program Memorandum (CONFIDENTIAL), PM #53, Headquarters, Department of the Army, Deputy Director, Research and Engineering, 28 February 1974, subject: Development Program (PIP) for AH-1Q (TOW) Flight Performance Improvement.

16. Final Report, USAASTA, Project No. 72-30, *Engineering Flight Test, AH-1G Helicopter with Model 212 Tail Rotor, Part I, Load Survey*, June 1973.

APPENDIX B. AIRCRAFT DESCRIPTION

GENERAL

1. The YAH-1S fuselage is nearly identical in outward appearance and dimensions to the AH-1Q helicopter. Internal modifications to the fuselage to accept the higher stresses due to increased gross weight, power, and tail rotor are stated in paragraph 8 of this appendix. Descriptive photographs are included in this appendix.

ENGINE

2. A T53-L-703 engine is installed in the YAH-1S helicopter, reflecting a growth from the T53-L-13B engine. The T53-L-703 turboshaft engine employs a two-stage axial flow free power turbine. A two-stage axial flow compressor turbine drives a combination five-stage axial, one-stage centrifugal compressor having a nominal 8:1 compression ratio at the thermodynamic limit. The engine also employs compressor interstage air bleed, variable inlet guide vanes, and an external annular atomizing combustor. A 3.2105:1 reduction gear housed in the air inlet housing reduces power turbine speed to output shaft speed (nominally 6600 rpm output shaft speed). The engine reduction gearbox is limited to 1175 ft-lb torque for 30 minutes and 1110 ft-lb torque for continuous usage. The engine achieves this power growth over the T53-L-13B engine through increased gas producer speed and increased operating temperatures made possible by improving the air cooling of the first-stage gas producer nozzle and by incorporating air-cooled blades in the first-stage turbine. New materials are employed in the second-stage gas producer and the power turbines. A T7 interstage turbine temperature sensor harness has been incorporated for measurement of interstage turbine temperature, giving a more accurate indication of engine internal temperatures than the T9 temperature (exhaust gas) sensed in the T53-L-13B engine. T7 temperature is displayed in the cockpit in place of T9. This is noticeable in the higher temperature limit on the gage and in the shorter temperature rise time on starting the engine.

TRANSMISSION AND TAIL ROTOR DRIVE

3. An uprated transmission and tail rotor were evolved, using AH-1J modified components, and installed in the YAH-1S helicopter. The main transmission has a 1290 shp 30-minute limit and an 1134 maximum continuous shp limit at a rotor speed of 324 rpm. The tail rotor drive system has a 187 shp maximum continuous power limit and a 260 shp 4-second transient limit.

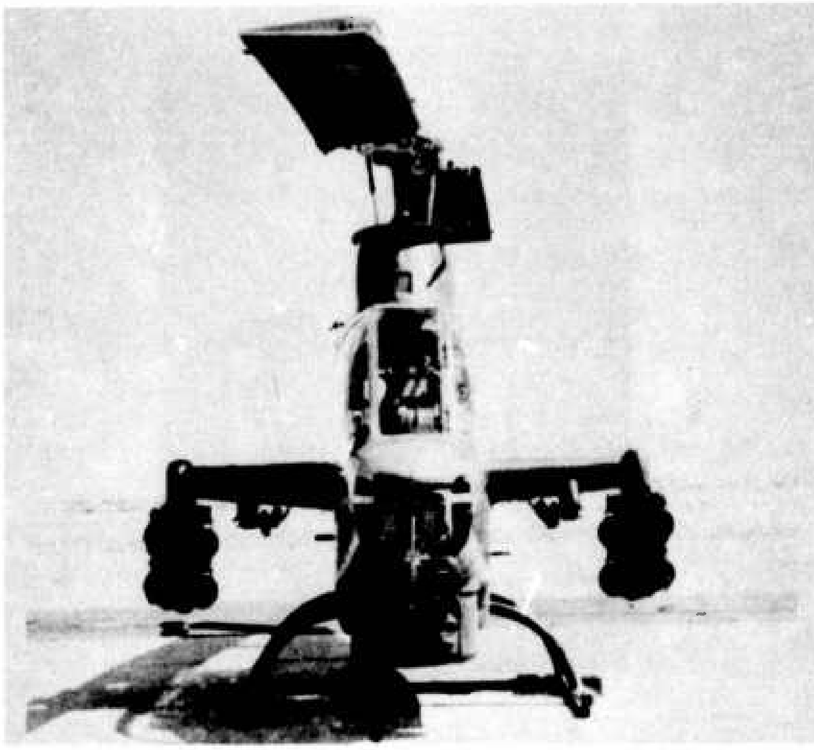


Photo 1. Front View, 8-TOW Configuration, YAH-1S Helicopter

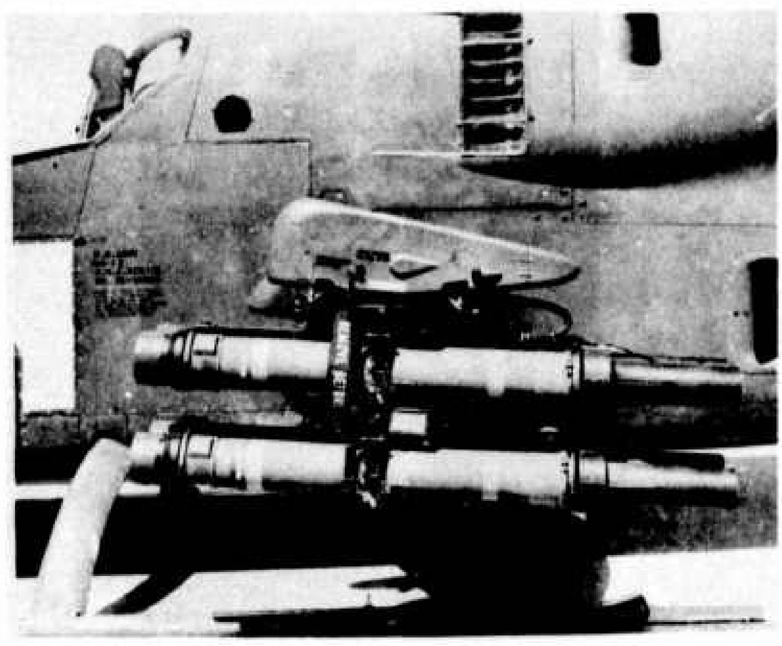


Photo 2. Left Side View, Dual-TOW Missile Launcher, YAH-1S Helicopter.

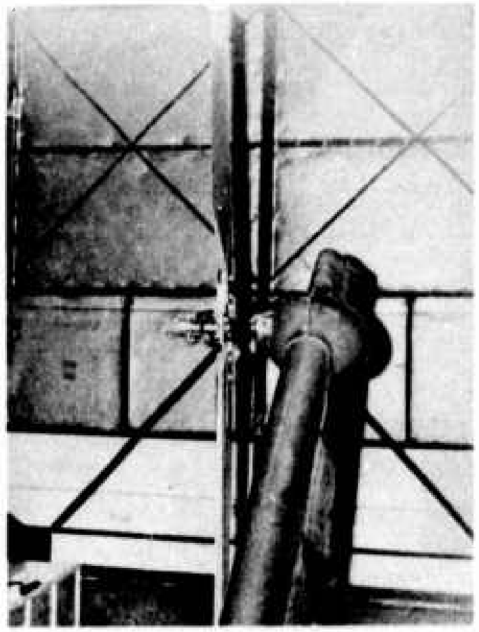


Photo 3. Front View, 90-Degree Gearbox, YAH-1S Helicopter.

Photo 4. Right Side, Model 212 Tail Rotor, YAH-1S Helicopter.

ENGINE OIL COOLER

4. The cooling capacity of the engine oil cooler has been increased by enlarging the bleed air orifice and the turbine oil cooler fan, thereby allowing a higher cooling fan speed and greater cooling air mass flow.

CONTROL SYSTEM

5. The control system of the YAH-1S helicopter is identical to the AH-1G/Q helicopter, with the exception of the antitorque rotor and collective controls. The cable controls in the antitorque system have been replaced by push-pull tubes. A collective control rate limiter has been incorporated which limits the rate of collective control movement to 115 percent of full throw in 1 second.

PRINCIPAL DIMENSIONS

6. Principal dimensions and general data concerning the YAH-1S helicopter are as follows:

Overall Dimensions

Length, rotors turning	52 ft, 11 in.
Width, rotor turning	44 ft
Height, tail rotor vertical	13 ft, 9.5 in.
Length, rotor removed	45 ft, 2.2 in.

Main Rotor

Diameter	44 ft
Disc area	1520.2 ft^2
Solidity	C.0651
Number of blades	2
Blade chord, constant	27.0 in.
Blade twist	-0.455 deg/ft
Airfoil	9.33 percent thickness, special symmetrical section

Tail Rotor

Diameter	8 ft, 6 in.
Disc area	56.75 ft^2
Solidity	0.1436
Number of blades	2
Blade chord, constant	11.5 in.
Blade twist	0.0 deg/ft
Airfoil	NACA 0018 at blade root, changing linearly to special cambered section with thickness ratio of 8.27% at the tip
Directional control rigging	Full left, +19.4 deg Full right, -11.4 deg

Fuselage

Length, rotor removed	45 ft, 2.2 in.
Height:	
To tip of tail fin	10 ft, 4 in.
Ground to top of mast	11 ft, 7 in.
Ground to top of transmission fairing	10 ft, 2 in.
Ground to bottom of chin turret	1 ft, 2 in.
Width:	
Fuselage only	3 ft
Wing span	10 ft, 8.24 in.
Engine cowling	3 ft, 6 in.
Skid gear tread	7 ft, 4 in.
Elevator:	
Span	6 ft, 2 in.
Area	25.2 ft^2
Airfoil	Inverted Clark Y
Vertical fin:	
Area	18.5 ft^2
Airfoil	Special cambered
Height	5 ft, 6 in.
Wing:	
Span	10 ft, 8.24 in.
Area	27.8 ft^2
Incidence	14 deg
Airfoil (root)	NACA 0030
Airfoil (tip)	NACA 0024

WEIGHT AND BALANCE

7. The aircraft weight and cg were determined before testing. With fuel tanks drained and with full instrumentation, the aircraft weight was 6606 pounds and the cg location was 202.8 inches. Total fuel capacity was determined to be 254 gallons.

8. The general arrangement and improvement changes caused the following weight increases per BHC Report No. 209-947-200.

Item		Weight (lb)
Tail group		1.2
Change to AH-1J tail rotor blades and hub		
Body group		20.5
Strengthen vertical fin	3.0	
Strengthen tail boom	5.0	
Strengthen transmission support	6.0	
Strengthen lift beam	4.0	
Strengthen diagonal strut end fittings	2.0	
Strengthen lift link	0.5	
Control group		1.6
Change to AH-1J push-pull tail rotor controls		
Engine section		2.0
Strengthen engine mounts		
Propulsion		35.2
Change to T53-L-703 engine	5.0	
Enlarge engine oil cooling system	5.0	
Change to main transmission	11.6	
Change to 42-degree gearbox	2.6	
Change to 90-degree gearbox	11.0	
Total empty weight increase		60.5

9. The following sample loading depicts the YAH-1S configured to its maximum gross weight and illustrates its load-carrying capability.

Item	Weight (lb)
Basic aircraft (based on AH-1Q per BHC specification 209-947-150, plus weight increase noted in para 8 of this appendix)	6,361
Trapped fuel and oil	65
Stores pylons	79
Helmet modification	1
Crew	400
Fuel (based on 254 gal. at a fuel specific weight of 6.5 lb/gal.)	1,651
7.62mm ammunition drum	63
7.62mm ammunition (3000 rounds)	195
M157B pod (2)	134
M229/M429 rockets (14)	395
TOW launchers (4)	240
TOW missiles (8)	416
Total	10,000

APPENDIX C. INSTRUMENTATION

1. Instrumentation was installed in the test aircraft by BHC. A test boom was mounted on the nose of the aircraft and the following sensors were mounted on the boom: a swiveling pitot-static head, sideslip vane, and angle-of-attack vane. The pitot-static source was located 6-1/2 feet in front of the nose of the aircraft. All instrumentation was calibrated by USAAEFA and BHC personnel, and USAAEFA maintained the instrumentation once the test program began. Pulse code modulated (PCM) and frequency modulated (FM) data were obtained from this calibrated sensitive instrumentation and were recorded on magnetic tape and/or displayed in the cockpit. Photo 1 shows the airborne system installed in the ammunition bay of the helicopter.

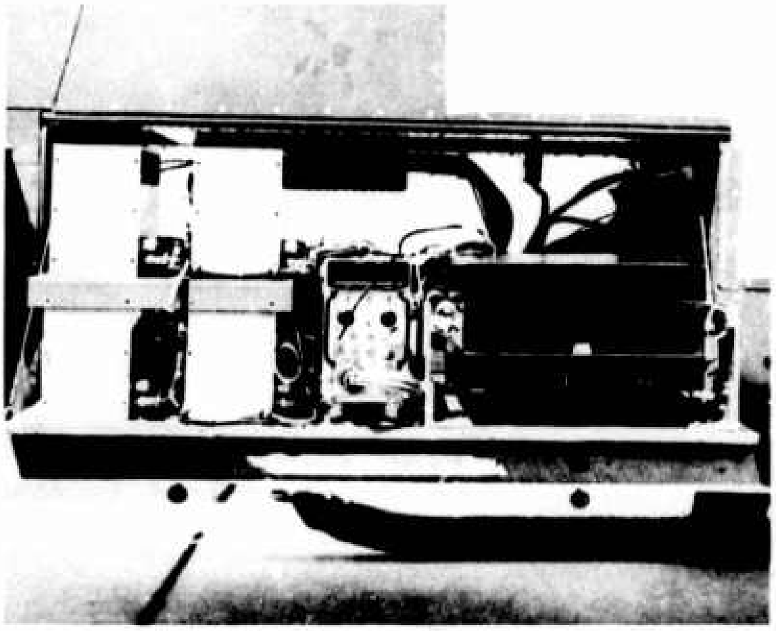


Photo 1. Airborne Data System.

2. Data parameters displayed are listed below:

Pilot Panel

Airspeed (boom)
Altitude (boom)
Altitude (radar)
Rate of climb (boom)
Rotor speed
Engine torque
Measured gas temperature (T_7)
Gas generator speed
Control position:
  Longitudinal
  Lateral
  Directional
  Collective
Center-of-gravity normal acceleration
Angle of sideslip
Tail rotor torque
Event switch

Copilot/Engineer Panel

Airspeed (ship's system)
Airspeed (boom)
Altitude (boom)
Rate of climb (boom)
Rotor speed
Engine torque (ship's)
Measured gas temperature (T_7)
Gas generator speed
Outside air temperature
Fuel flow
Fuel used (totalization)
Load cell
Time code display
Event switch
Instrumentation controls and lights

3. Data parameters recorded on tape were as follows:

<u>**Digital (PCM) Parameters**</u>

Fuel totalizer
Control position:
- Longitudinal
- Lateral
- Directional
- Collective

Sideslip angle
Angle of attack
Control force:
- Longitudinal
- Lateral
- Directional

Center-of-gravity acceleration:
- Normal
- Lateral
- Longitudinal

SCAS actuator extension:
- Longitudinal
- Lateral
- Directional

Throttle position
Engine inlet total pressure
Engine inlet temperature
Angular acceleration:
- Pitch
- Roll
- Yaw

Altitude (boom)
Airspeed (boom)
Gas generator speed
Engine output shaft speed
Main rotor speed
Outside air temperature
Engine fuel flow
Measured gas temperature (T_7)
Main rotor shaft torque
Engine torque pressure
Tail rotor shaft torque
Fuel temperature at engine

Angular rate:
- Pitch
- Roll
- Yaw

Attitude:
- Pitch
- Roll
- Yaw

Load cell reading
Altitude (radar)
Tail rotor blade pitch angle
Time of day
Pilot event
Engineer event

<u>FM Parameters</u>

Pilot seat acceleration:
- Vertical
- Lateral
- Longitudinal

Copilot seat acceleration:
- Vertical
- Lateral
- Longitudinal

Instrument panel acceleration:
- Vertical
- Lateral
- Longitudinal

Main rotor shaft index
Main rotor cyclic blade angle
Main rotor teetering angle
Main rotor pitch link load
Tail rotor shaft index
Tail rotor pitch link load

4. Mechanical fixtures were used in the forward cockpit to obtain desired control inputs during controllability testing.

5. Figures 1 and 2 graphically depict the equations used for determining engine torque and calibrated airspeed.

FIGURE 1
ENGINE CHARACTERISTICS

T53-L-703 S/N K-204

NOTE: POINTS OBTAINED FROM ENGINE CALIBRATION TEST CONDUCTED 30 AUG 74.

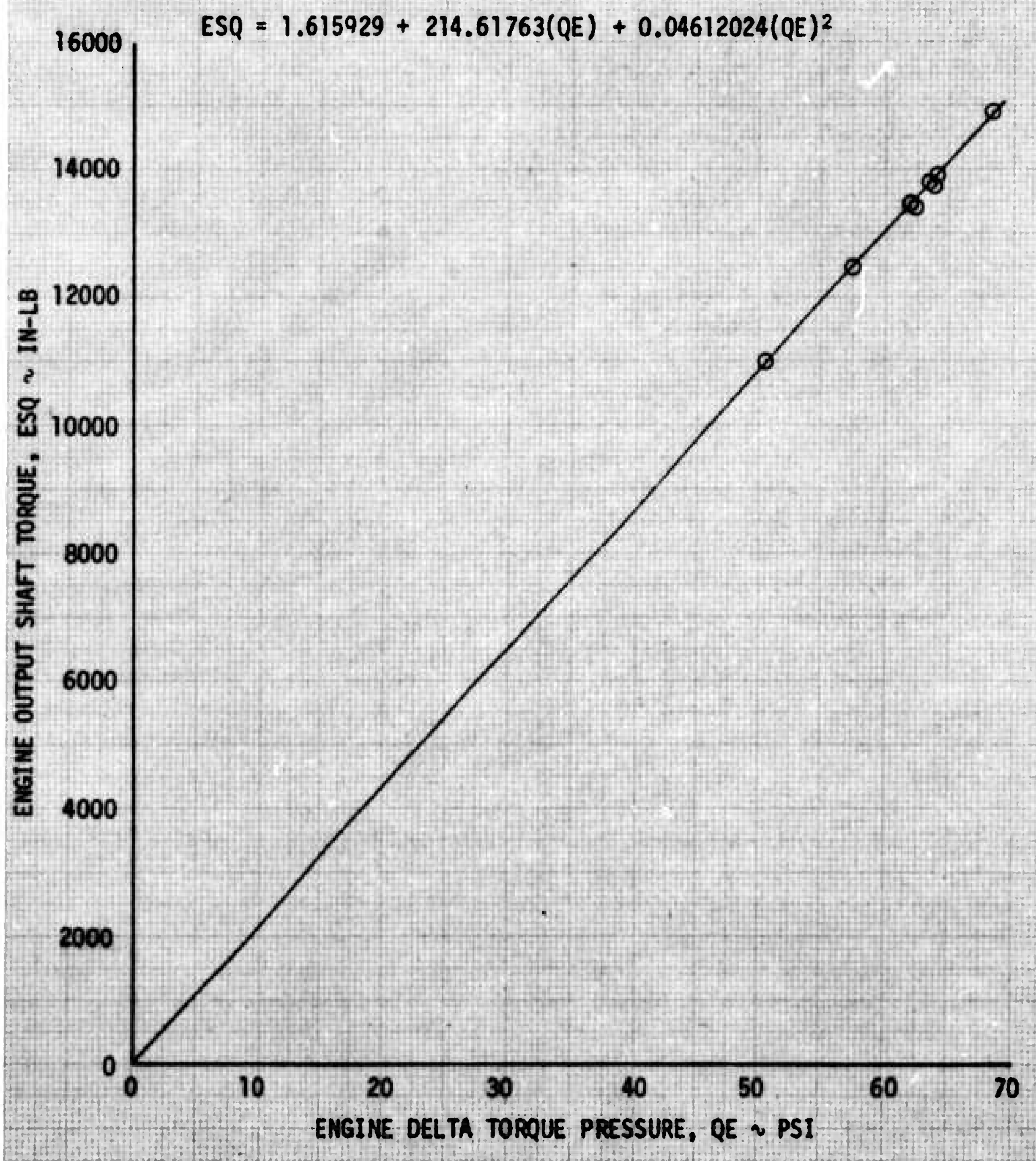
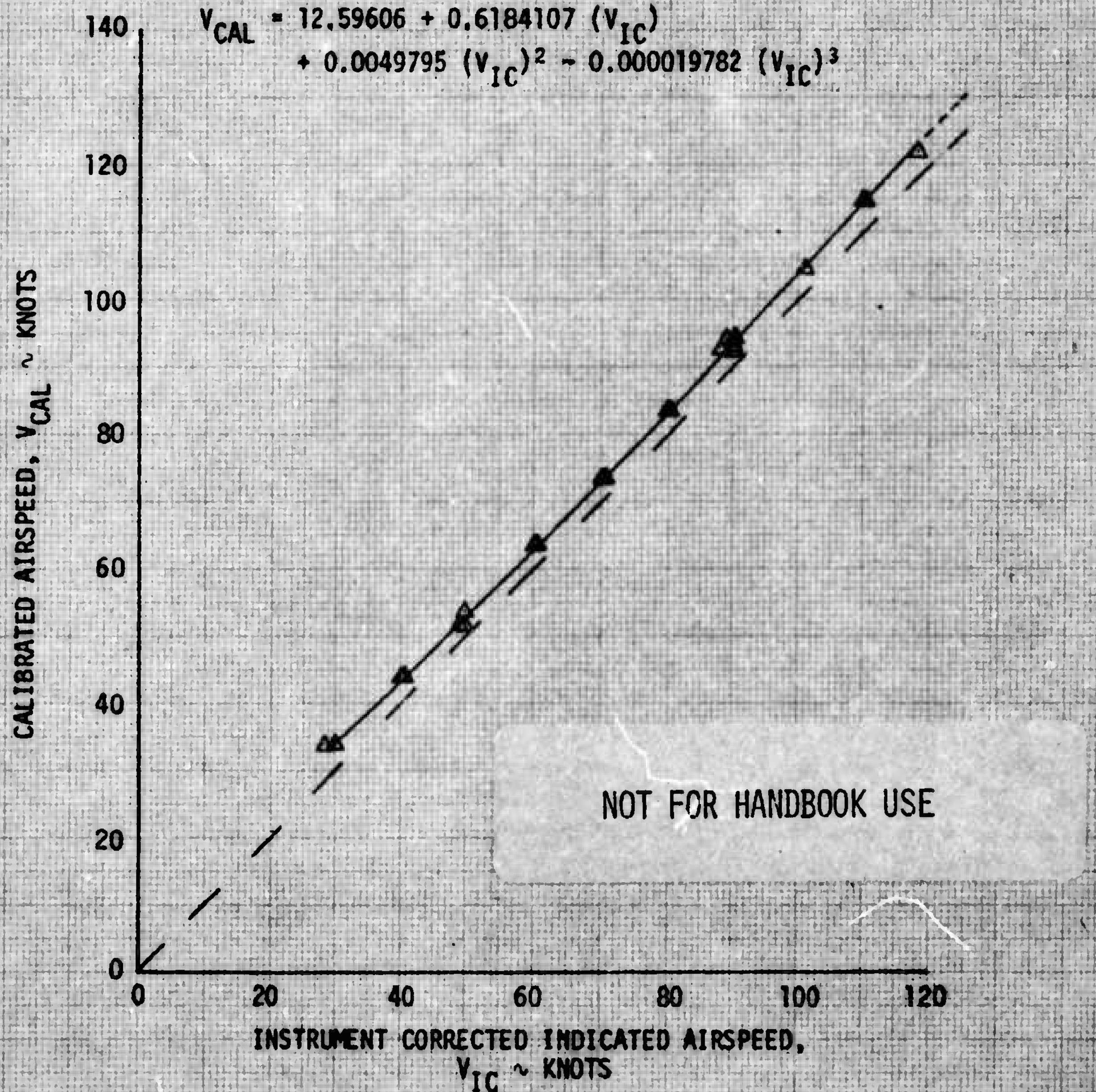


FIGURE 2
AIRSPEED CALIBRATION

YAH-1S USA S/N 70-16055

BOOM SYSTEM

NOTES:
1) TRAILING BOMB METHOD.
2) ROTOR SPEED = 324 RPM.
3) LEVEL FLIGHT CONDITION.
4) DENSITY ALTITUDE = 7400 FT.
5) AMBIENT TEMPERATURE = 14.0°C.
6) THE BOOM-MOUNTED PITOT-STATIC SOURCE WAS LOCATED 6 1/2 FEET FROM IN FRONT OF THE NOSE OF THE AIRCRAFT.



APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

TEST TECHNIQUES

Aircraft Weight and Balance

1. The aircraft weight and longitudinal and lateral cg were determined prior to testing. Two weighings were accomplished: the first with all fuel drained, and the second with a full fuel load. Both weighings included instrumentation and neither included external stores. The engine, pilot, and gunner armor plating, except for that plating mounted to the gunner canopy door, was removed prior to the weighings and for the duration of the test. The first weighing (fuel drained) was 6606 pounds with the longitudinal cg located at fuselage station (FS) 202.8. The second weighing (full fuel) was 8263 pounds with the longitudinal cg located at FS 202.0.

2. The fuel load for each test flight was determined prior to engine start and after engine shutdown. Total fuel load was determined by measuring the fuel specific gravity and temperature, and by using an external sight gage on the fuel cell to determine fuel volume. This sight gage was calibrated by leveling the helicopter through its longitudinal and lateral axes and noting the readings on the externally attached gage as fuel was added in 5-gallon increments. Fuel used in flight was recorded by a calibrated fuel-used system and the final fuel-used reading following engine shutdown was cross-checked with the sight gage readings following each flight.

3. Aircraft gross weight and cg were controlled by installing ballast at several fuselage stations.

Hover Performance

4. Hover performance parameters were determined using the tethered hover technique as described in Army Materiel Command Pamphlet AMCP 706-204 (ref 11, app A). Two hover heights were tested: skid heights of 5 feet (IGE) and 100 feet (OGE). With the aircraft tethered to the ground by a steel cable, engine torque was varied from that required to maintain a minimum 200-pound cable tension to the maximum defined either by the 30-minute torque limit (55.7 psi) or by reaching topping power. (For this test, topping power was determined by an inability to further increase collective and still maintain the desired rotor speed.) This torque range was repeated for main rotor speeds of 294, 310, and 324 rpm at each skid height. During the test, the aircraft was maintained in a position to keep the cable vertical with respect to the ground, through voice or hand signals

from two observers located to observe the longitudinal and lateral position of the helicopter. Atmospheric pressure, temperature, and wind velocity were recorded from a ground weather station. All hover testing was conducted in winds of less than 3 knots.

Level Flight Performance

5. Level flight performance parameters were determined utilizing the constant weight-to-density ratio (W/σ) method described in AMCP 706-204. This method allows the entire flight to be flown at a constant value of the nondimensional parameter C_T, defined in paragraph 13. The aircraft was stabilized at zero sideslip at airspeeds between 30 knots indicated airspeed (KIAS) and V_H as limited by engine power available. The altitude for each test point was determined from current aircraft weight and ambient density (determined from pressure altitude and ambient temperature). All test points were flown at a main rotor speed of 324 rpm. The helicopter was flown for a minimum of 2 minutes at each stabilized test condition.

Control System Characteristics

6. Tests were conducted with the aircraft in a static condition on the ground, utilizing external power sources to pressurize both hydraulic flight control systems. Breakout forces and force gradients were determined by displacing the control from a trim position at a rate of 0.1 to 0.15 inch per second and recording the forces applied and the stick displacement.

Control Positions in Trimmed Forward Flight

7. Control positions in trimmed forward flight were evaluated in conjunction with level flight performance tests. Data were obtained by stabilizing at zero sideslip at 10-knot increments, trimming the control forces to zero, and recording control positions and aircraft attitude.

Controllability

8. Tests were conducted in hovering and low-speed flight. Once stabilized at the desired flight condition, data were obtained by rapidly applying step control inputs of different magnitude separately to the longitudinal, lateral, and directional axes. These inputs were held until the maximum rate was reached or recovery was necessary, with the resulting aircraft motion recorded.

Low-Speed Flight

9. Tests were conducted at a skid height of approximately 15 feet at various relative wind azimuths measured from the nose of the aircraft. At each selected test azimuth, airspeed was increased in 5-knot increments from hover to the flight envelope limit. A calibrated fifth wheel mounted on a pace vehicle was used as a speed reference at Bishop Airport. The calibrated speedometer of a snowmobile was used as a speed reference at Coyote Flats where 2.5 feet of level snow covered the runway.

DATA ANALYSIS METHODS

Airspeed Calibration

10. The calibration of the airspeed system was accomplished by determining the existing airspeed position error of the test nose boom in level flight. A calibrated trailing bomb was used as the standard.

11. A mathematical curve fit was applied to the data and is graphically presented in figure 2, appendix C. Calibrated airspeed (V_{cal}) is shown as a function of instrument-corrected indicated airspeed (V_{ic}) in the following equation.

$$V_{cal} = 12.59606 + 0.6184107\ (V_{ic}) + 0.0049795\ (V_{ic})^2 - 0.000019782\ (V_{ic})^3 \qquad (1)$$

12. True airspeed (V_T) is calculated using V_{cal} and density ratio (σ).

$$V_T = V_{cal}/\sqrt{\sigma}$$

Nondimensional Method

13. The helicopter performance results may be generalized through the use of nondimensional coefficients. The test results obtained at specific test conditions may be used to accurately define performance at conditions not tested. The following nondimensional parameters were used.

$$\text{Thrust coefficient} = C_T = \frac{\text{Thrust}}{\rho A(\Omega R)^2} \qquad (2)$$

$$\text{Power coefficient} = C_P = \frac{\text{SHP}(550)}{\rho A(\Omega R)^3} \qquad (3)$$

$$\text{Advance ratio} = \mu = \frac{V_T \cos\alpha}{\Omega R} \cong \frac{V_T}{\Omega R} \qquad (4)$$

Where:

ρ = Air density (slug/ft^3)

A = Main rotor disc area (ft^2)

Ω = Main rotor angular velocity (**radians/sec**)

R = Main rotor radius (ft)

SHP = Shaft horsepower

V_T = True airspeed (ft/sec)

α = Angle of attack (deg)

Thrust = Gross weight (lb) during free flight in which there is no acceleration or velocity component in the vertical direction; tether load must be added in the case of tethered hover

Performance

Power Determination:

14. The calibration of the engine torquemeter system for engine SN K204 is graphically presented in figure 1, appendix C. A mathematical curve fit was applied to the data and this curve was used to obtain engine output shaft torque (ESQ) in inch-pounds (in.-lb) as a function of engine output torque pressure (QE) in lb/in.^{2}. The equation of the curve is as follows.

$$ESQ = 1.615929 + 214.61763\,(QE) + 0.04612024\,(QE)^2 \qquad (5)$$

15. Engine shaft speed and tail rotor speed were determined as functions of main rotor speed using the following equations.

$$N_E = 20.383\,(N_R) \qquad (6)$$

$$N_{TR} = 5.10859\,(N_R) \qquad (7)$$

Where:

N_E = Engine shaft rotational speed (rpm)

N_R = Main rotor rotational speed (rpm)

N_{TR} = Tail rotor rotational speed (rpm)

16. Equations for engine output shp (SHP_T) and tail rotor shp (SHP_{TR}) are as follows.

$$SHP_T = \frac{2\pi}{(12)\ (33{,}000)} (N_E)\ (ESQ) \quad (8)$$

$$SHP_{TR} = \frac{2\pi}{(12)\ (33{,}000)} (N_{TR})\ (Q_{TR}) \quad (9)$$

Where:

Q_{TR} = Tail rotor torque (in.-lb) measured by strain gages through a slipring device at the 90-degree tail rotor gearbox

Hover Performance:

17. Hover data were converted to nondimensional parameters by use of equations 2 and 3 and grouped according to skid height. A line was faired through each set of data. Summary hovering performance (figs. 1 and 2, app E) was then calculated by converting these nondimensional plots and the power available presented in figure 7 at selected ambient conditions.

Level Flight Performance:

18. Level flight data were obtained by measuring the shp required to maintain level flight at various airspeeds. Constant C_T was maintained by increasing altitude as fuel was consumed.

19. Since the density altitude is continually changing throughout the test, the data are corrected to an average density altitude by use of the following equation.

$$SHP_S = SHP_T \left(\frac{\bar{\rho}}{\rho_t}\right)$$

Where:

$\bar{\rho}$ = Average air density for entire flight

ρ_t = Air density for specific test points

20. Curves defined by the power required as a function of airspeed were plotted as C_P versus μ for a constant value of C_T. These curves were then joined by lines of constant μ value to form a carpet plot. The reduction of this carpet plot into a family of curves, C_T versus C_P, for a constant μ value allows determination of the power required as a function of airspeed for any value of C_T.

21. The specific nautical air miles per pound of fuel (NAMPP) data were derived from the test level flight power required and specification engine fuel flow data.

Vertical Climb Performance:

22. Vertical climb tests were not performed. Therefore, it was necessary to compute climb performance from OGE hover data in conjunction with power-available curves.

23. Equation 8 in appendix B of reference 14, appendix A, shows the relationship between power and rate of climb at given gross weight and atmospheric conditions as follows.

$$P_C = T\nu_\nu + (GW)\,(V_V) + P_P + P_{oh}\,\left(1 + K_C\,\frac{V_V}{\Omega R}\right) \qquad (10)$$

Where:

P_C = Power required to climb (ft-lb/sec)

T = Thrust (lb) = $GW + 1/2\,\rho\,V_V^2\,A_Z$

ν_ν = Induced velocity in climb (ft/sec)

$$= \frac{-V_V + \sqrt{V_V^2 + 2C_T\,(\Omega R)^2}}{2}$$

GW = Gross weight (lb)

V_V = Vertical velocity (ft/sec)

P_P = Parasite power (ft-lb/sec) = $1/2\ \rho\ V_V{}^3\ A_Z$

P_{oh} = Hover profile power (ft-lb/sec) from OGE C_T vs C_P curve

A_Z = Flat plate area on vertical axis = 82 ft^2

K_c = Vertical rate-of-climb correction factor determined to be 1.9 for AH-1 series

24. This equation can generate a family of curves for power versus gross weight versus vertical velocity. These curves were used to generate the plot in figure 6, appendix E.

Handling Qualities

25. Handling qualities data were evaluated using standard test methods (ref 12, app A). The term "total control position" used on the plots in this report refers to pilot control input and SCAS input combined.

Structural Dynamics

Vibration:

26. The FM vibration data were reduced by means of a spectrum analyzer from the analog flight tape. Vibration levels, representing peak amplitudes, were extracted from this analysis at selected harmonics of the main rotor frequency and are listed in tables 1 through 12, appendix E.

Structural Loads:

27. The FM loads data were digitized at the rate of 500 samples per second from the flight tape and reduced through the use of USAAEFA computer facilities. Mean and oscillatory loads for selected flight conditions are listed in tables 13 and 14, appendix E. The mean load was defined as the average of the maximum and minimum loads recorded during one cycle of the fundamental oscillation. The oscillatory load was defined to be one-half the difference between the maximum and minimum loads recorded during one cycle of the fundamental oscillation. All load parameter zeros excluded static loads.

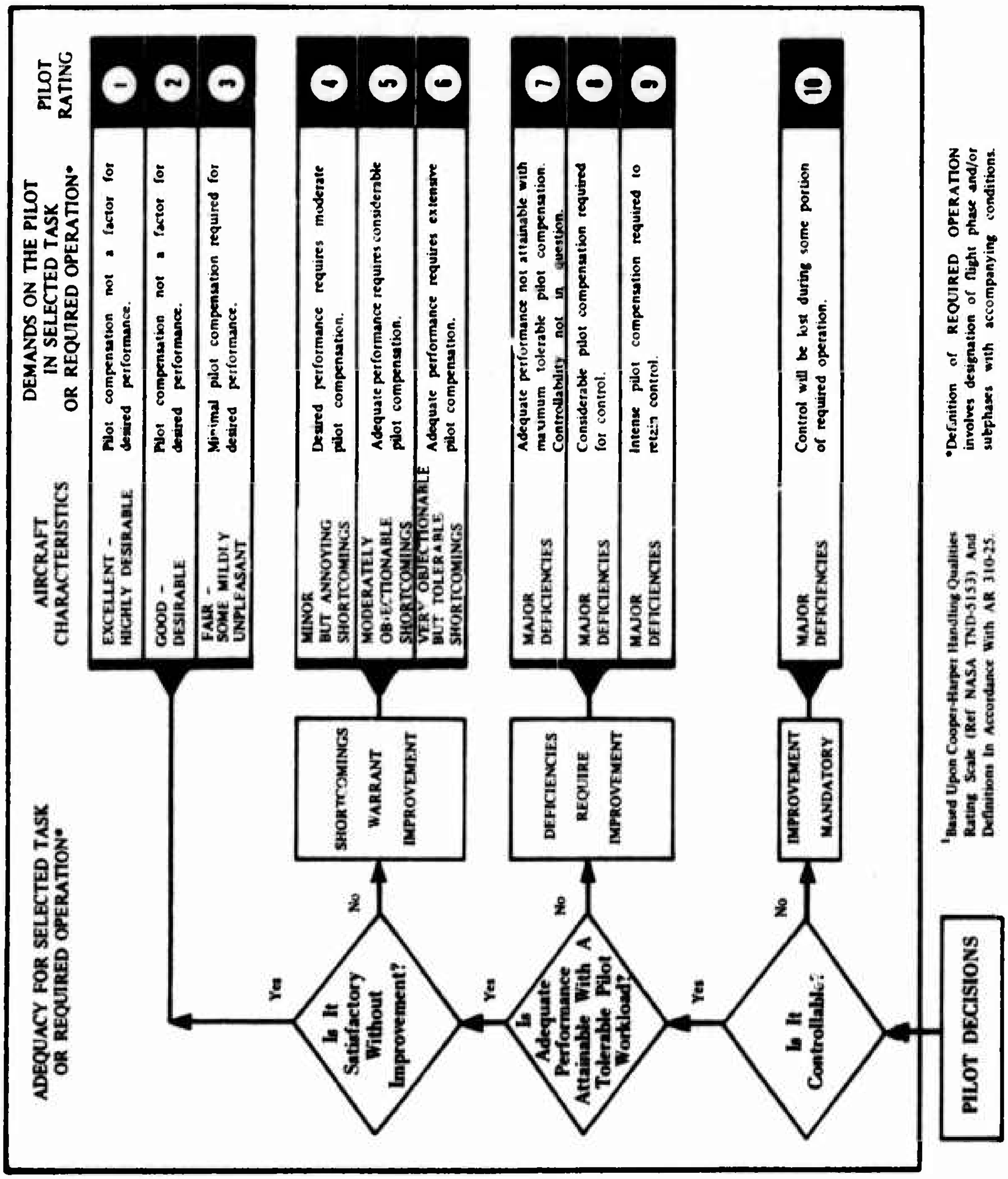


Figure 1. Handling Qualities Rating Scale.

APPENDIX E. TEST DATA

INDEX

FIGURE 1
SUMMARY IGE HOVERING PERFORMANCE

YAH-1S USA S/N 70-16055

MILITARY POWER AVAILABLE
ROTOR SPEED = 324 RPM
SKID HEIGHT = 5 FEET

NOTES: 1) SHP OBTAINED FROM FIGURE 5.
2) CURVES DERIVED FROM FIGURE 3.
3) BROKEN LINE DEPICTS 10 PERCENT DIRECTIONAL CONTROL MARGIN RESTRICTION.
4) MAXIMUM GROSS WEIGHT = 10,000 POUNDS.

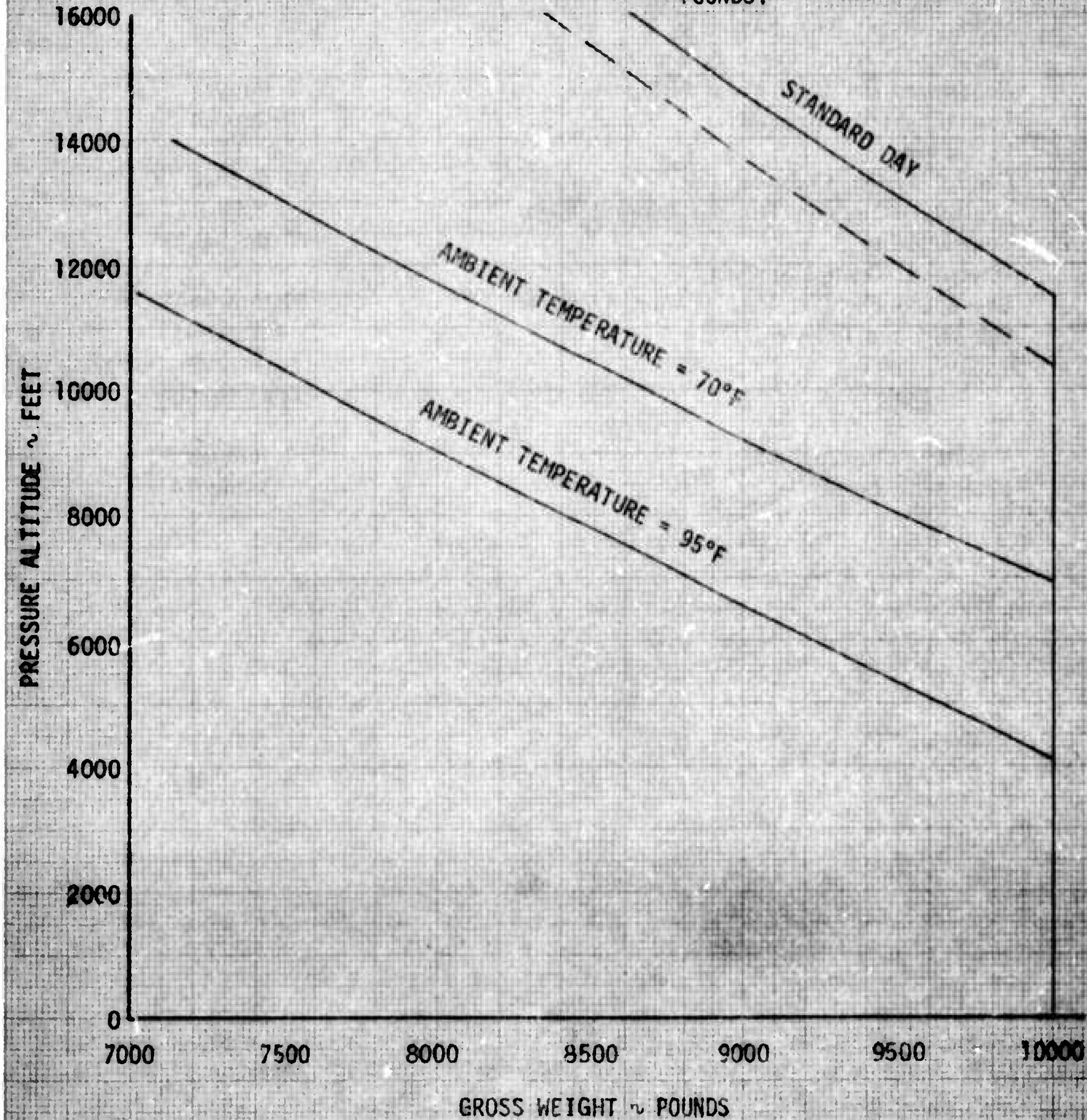


FIGURE 2
SUMMARY OGE HOVERING PERFORMANCE

YAH-1S USA S/N 70-16055

MILITARY POWER AVAILABLE
ROTOR SPEED = 324 RPM

NOTES: 1) SHP OBTAINED FROM FIGURE 5.
2) CURVES DERIVED FROM FIGURE 4.
3) MAXIMUM GROSS WEIGHT = 10,000 POUNDS.

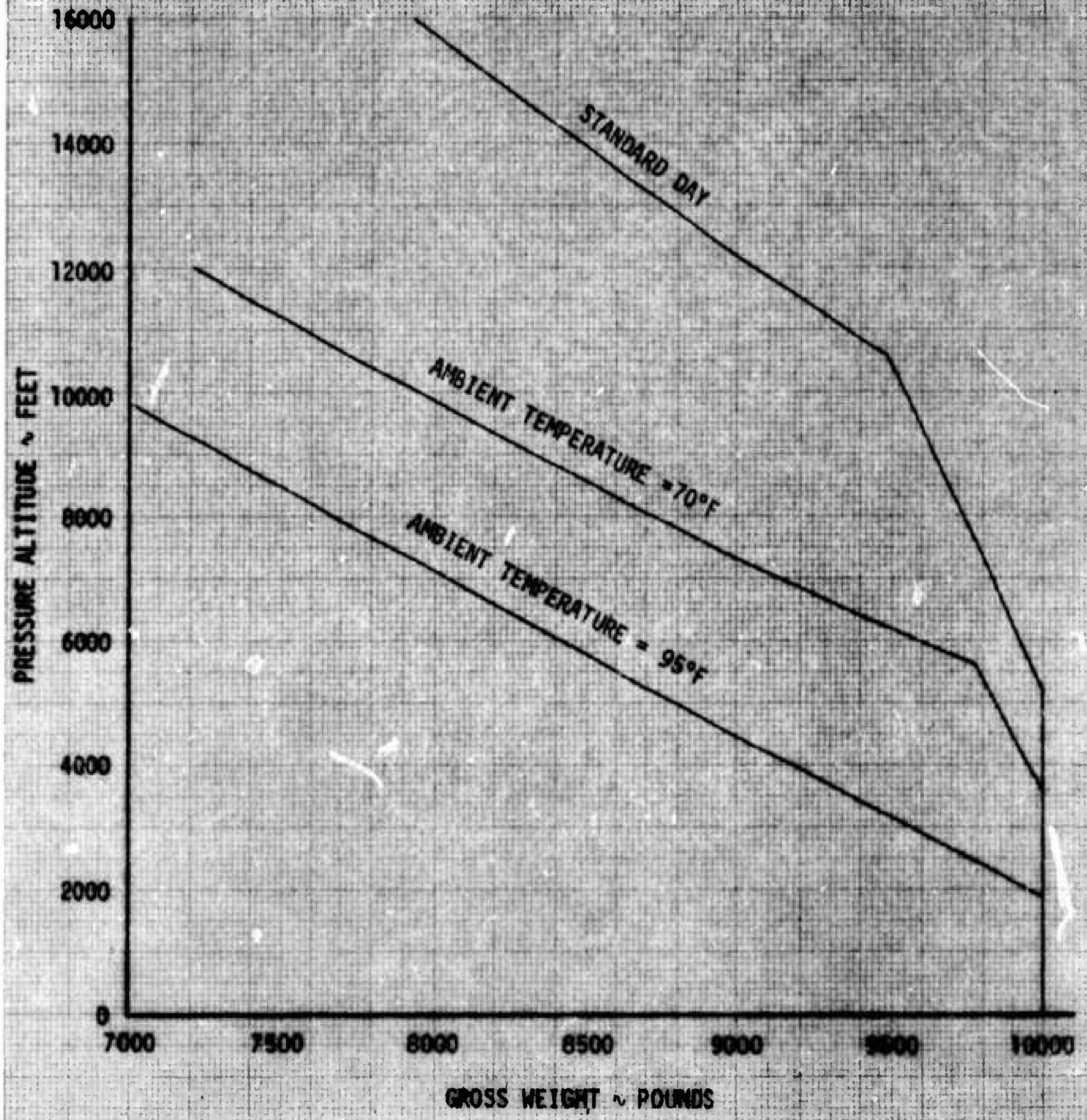


FIGURE 3
NON-DIMENSIONAL HOVERING PERFORMANCE
YAH-1S USA S/N 70-16055

IGE SKID HEIGHT = 5 FEET

NOTES:
1) VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.58 FEET.
2) WIND LESS THAN 3 KNOTS.
3) OPEN SYMBOLS DENOTE:
DENSITY ALTITUDE = 980 FT.
AMBIENT TEMPERATURE = 0.0°C.
4) SOLID SYMBOLS DENOTE:
DENSITY ALTITUDE = 910 FT.
AMBIENT TEMPERATURE = -15.0°C.
5) TETHERED HOVER METHOD.

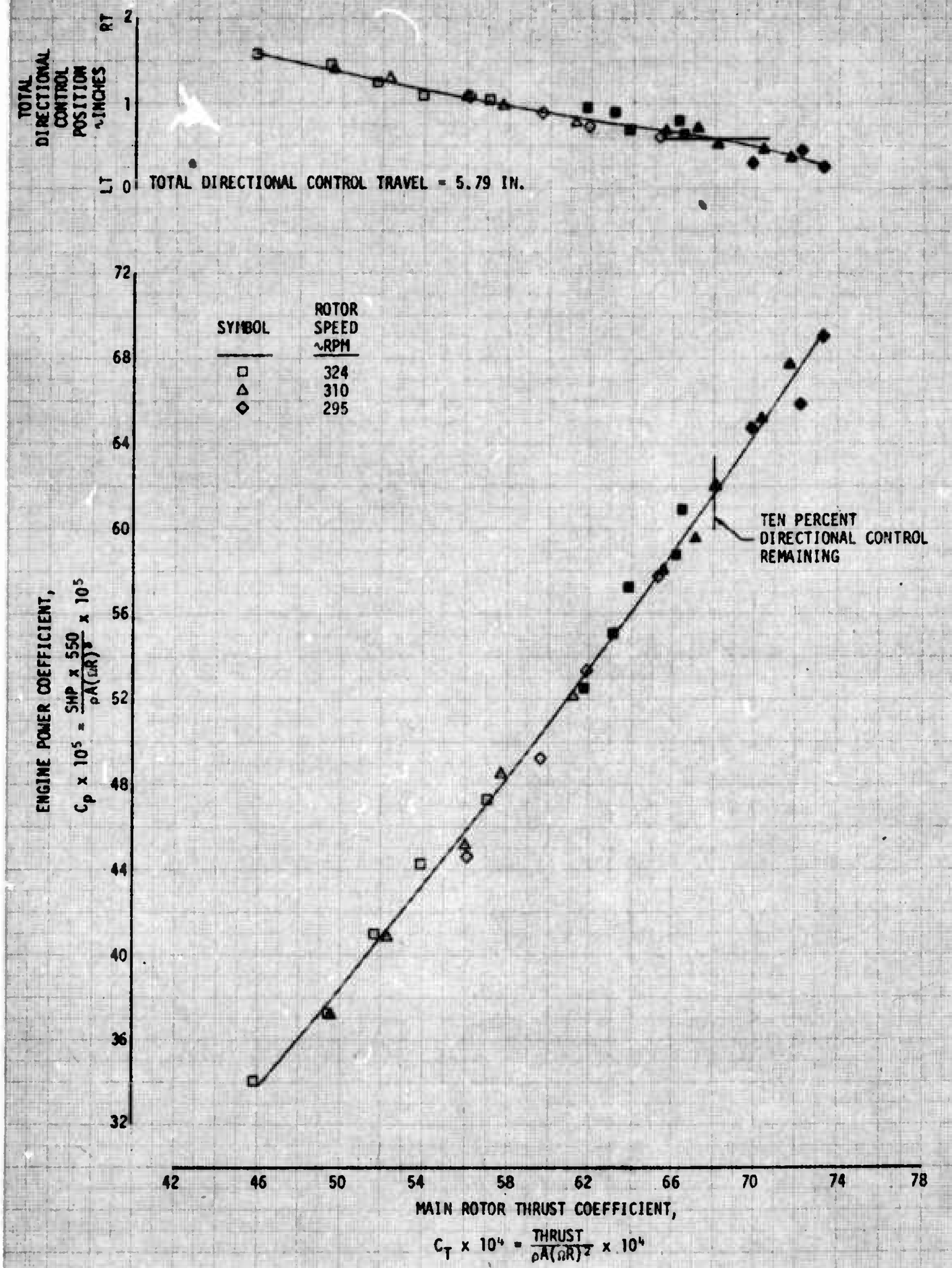


FIGURE 4
NON-DIMENSIONAL HOVERING PERFORMANCE
YAH-1S USA S/N 70-16056

OGE SKID HEIGHT = 100 FEET

NOTES:
1) VERTICAL HEIGHT FROM BOTTOM OF SKID TO CENTER OF ROTOR HUB = 11.58 FEET.
2) WIND LESS THAN 3 KNOTS.
3) OPEN SYMBOLS DENOTE:
DENSITY ALTITUDE = 1200 FT.
AMBIENT TEMPERATURE = 2.0°C.
4) SOLID SYMBOLS DENOTE:
DENSITY ALTITUDE = 9460 FT.
AMBIENT TEMPERATURE = -12.0°C.
5) TETHERED HOVER METHOD EXCEPT FLAGGED SYMBOLS WHICH DENOTE FREE FLIGHT.

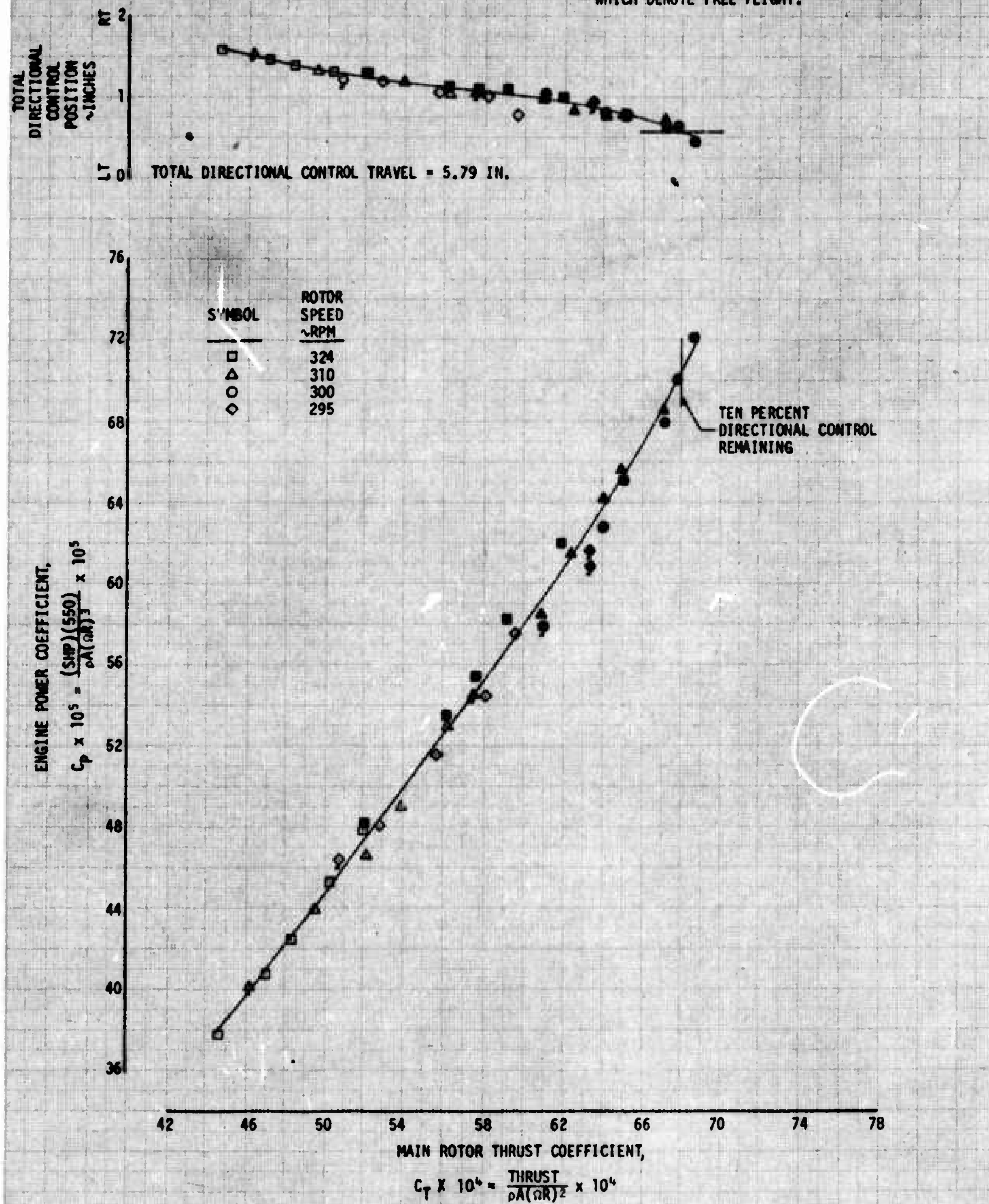


FIGURE 5

MILITARY SHAFT HORSEPOWER AVAILABLE

T53-L-703 ENGINE

NOTES: 1) DATA BASED ON LYCOMING T53-L-703 ENGINE MODEL SPECIFICATION NUMBER 104.43 AS PRESENTED IN YAH-1S SUPPLEMENT TO TM-55-1520-221-10.

2) ROTOR SPEED = 324 RPM.

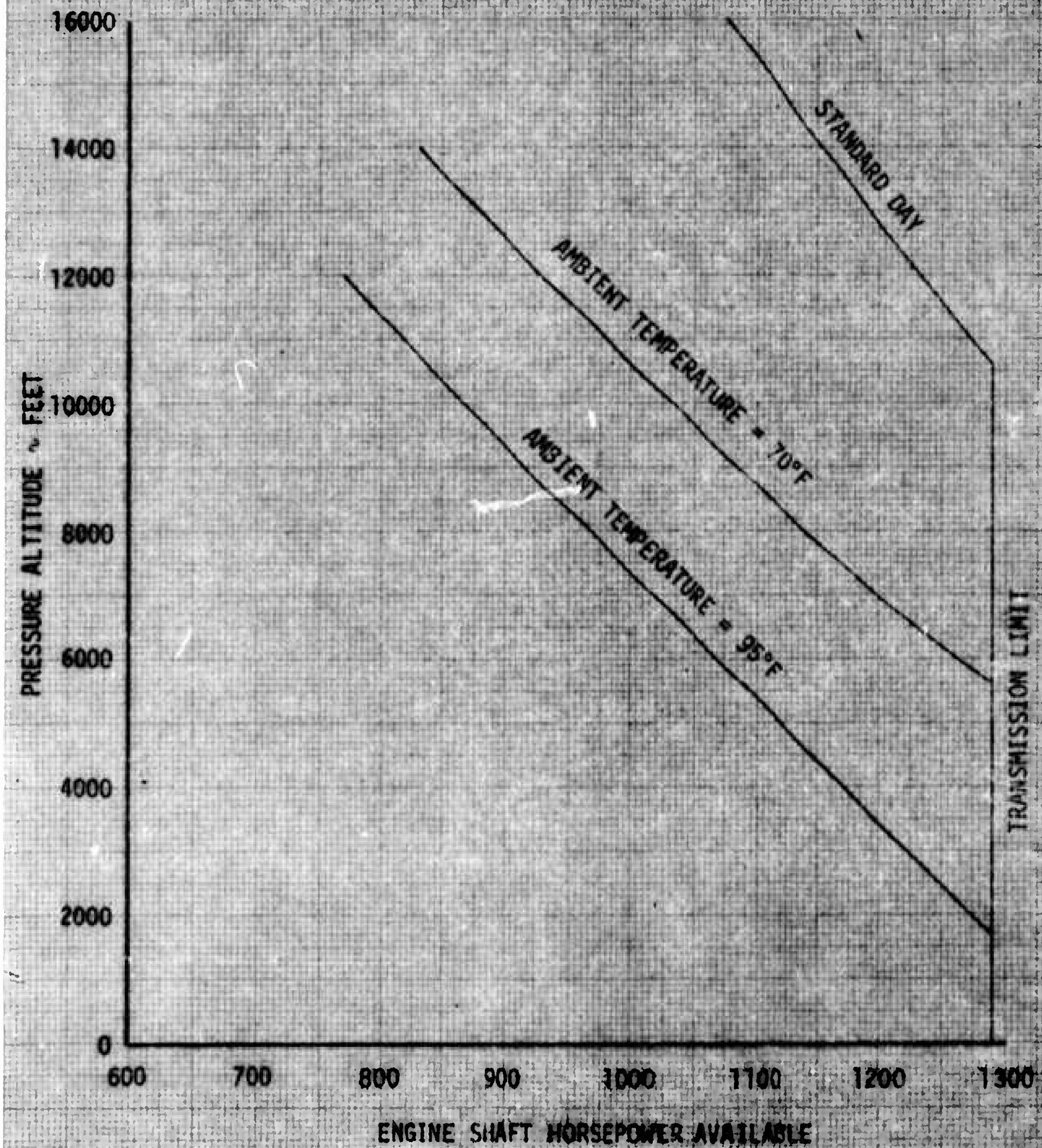


FIGURE 6
CALCULATED VERTICAL CLIMB PERFORMANCE
YAH-1S USA S/N 70-16055

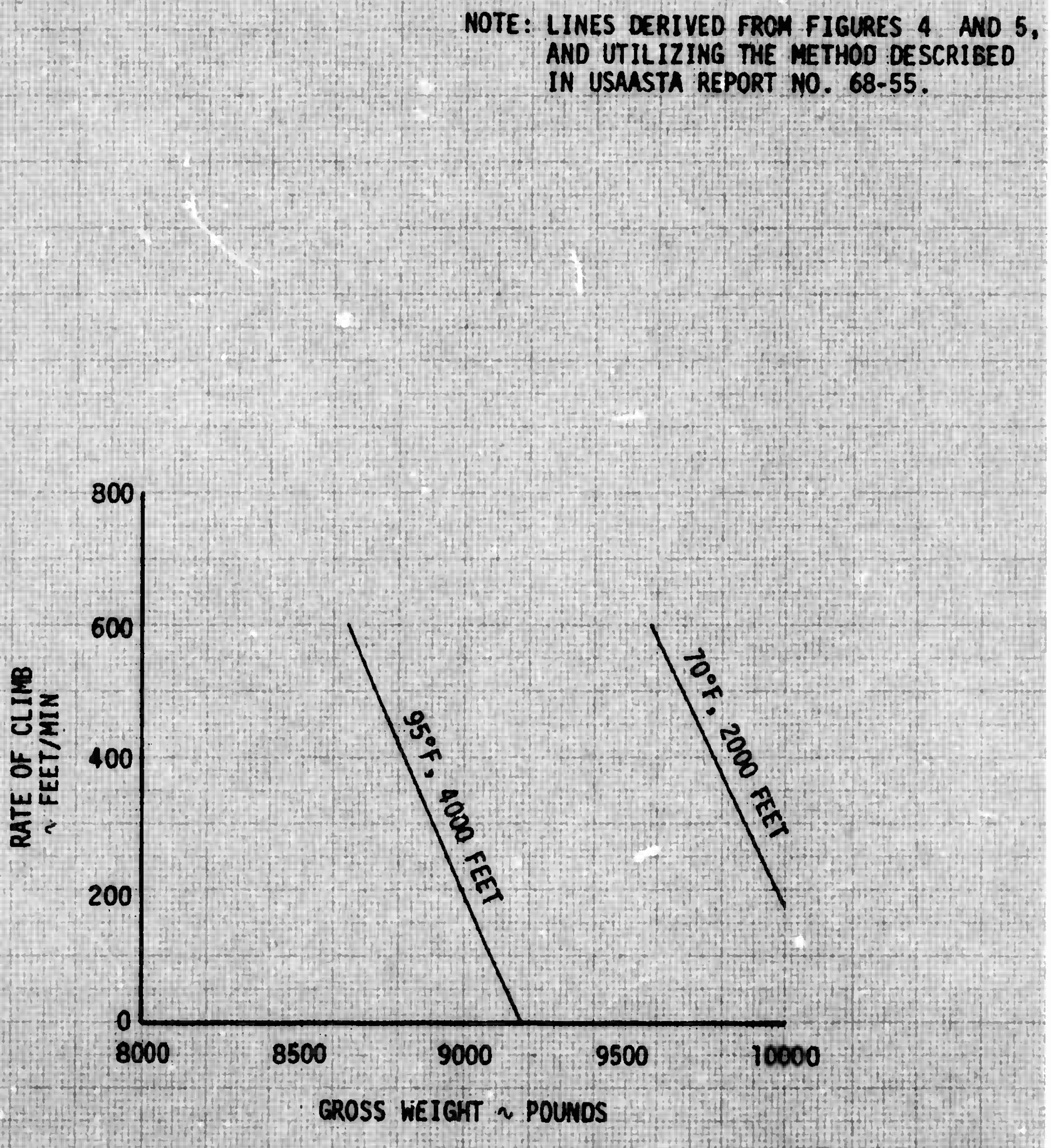


FIGURE 7

NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

CENTER OF GRAVITY = 192.4 IN. (FWD)

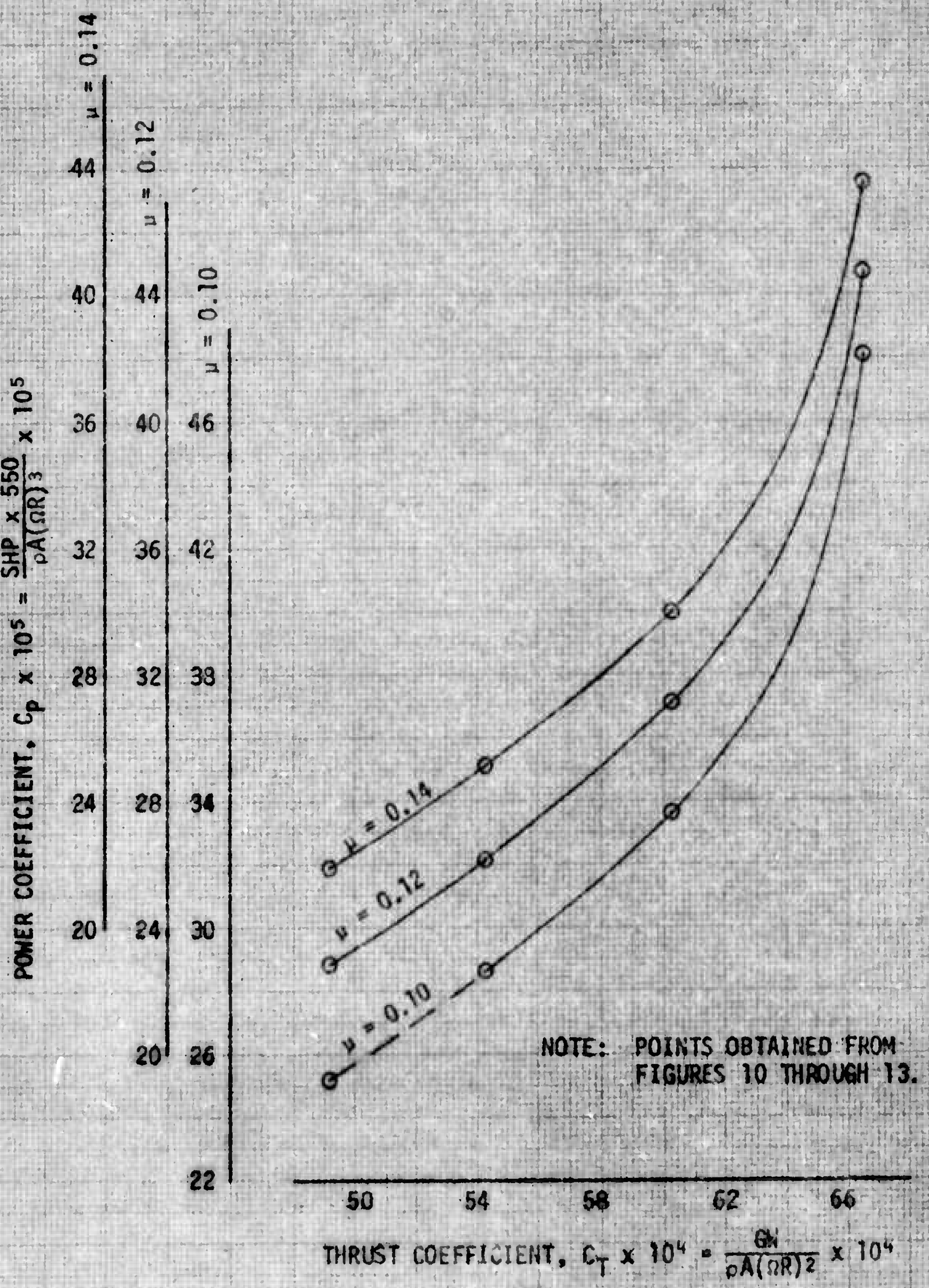


FIGURE 8

NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE

YAH-1S USA S/N 70-16058

8-TOW CONFIGURATION

CENTER OF GRAVITY = 192.4 IN. (FWD)

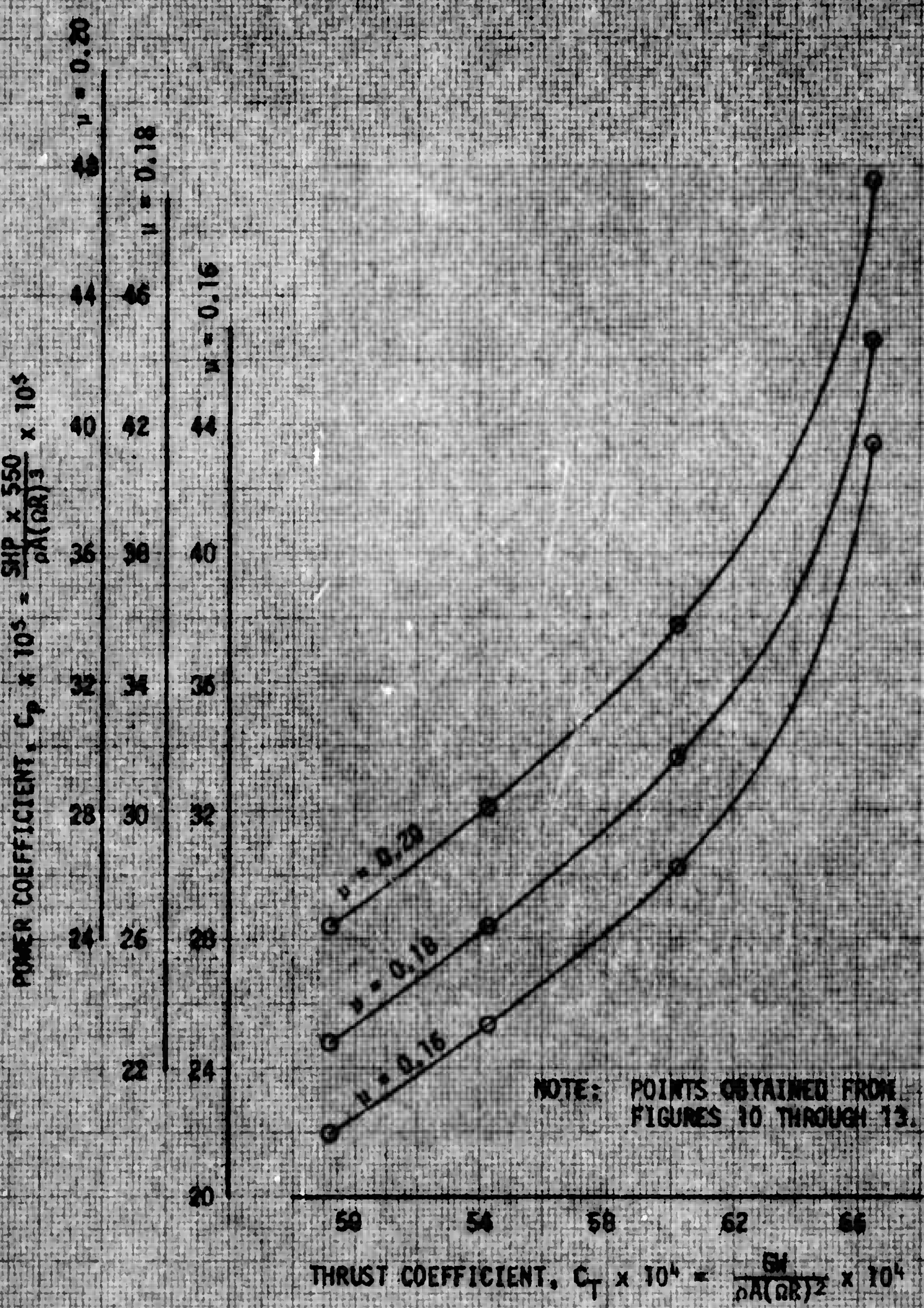
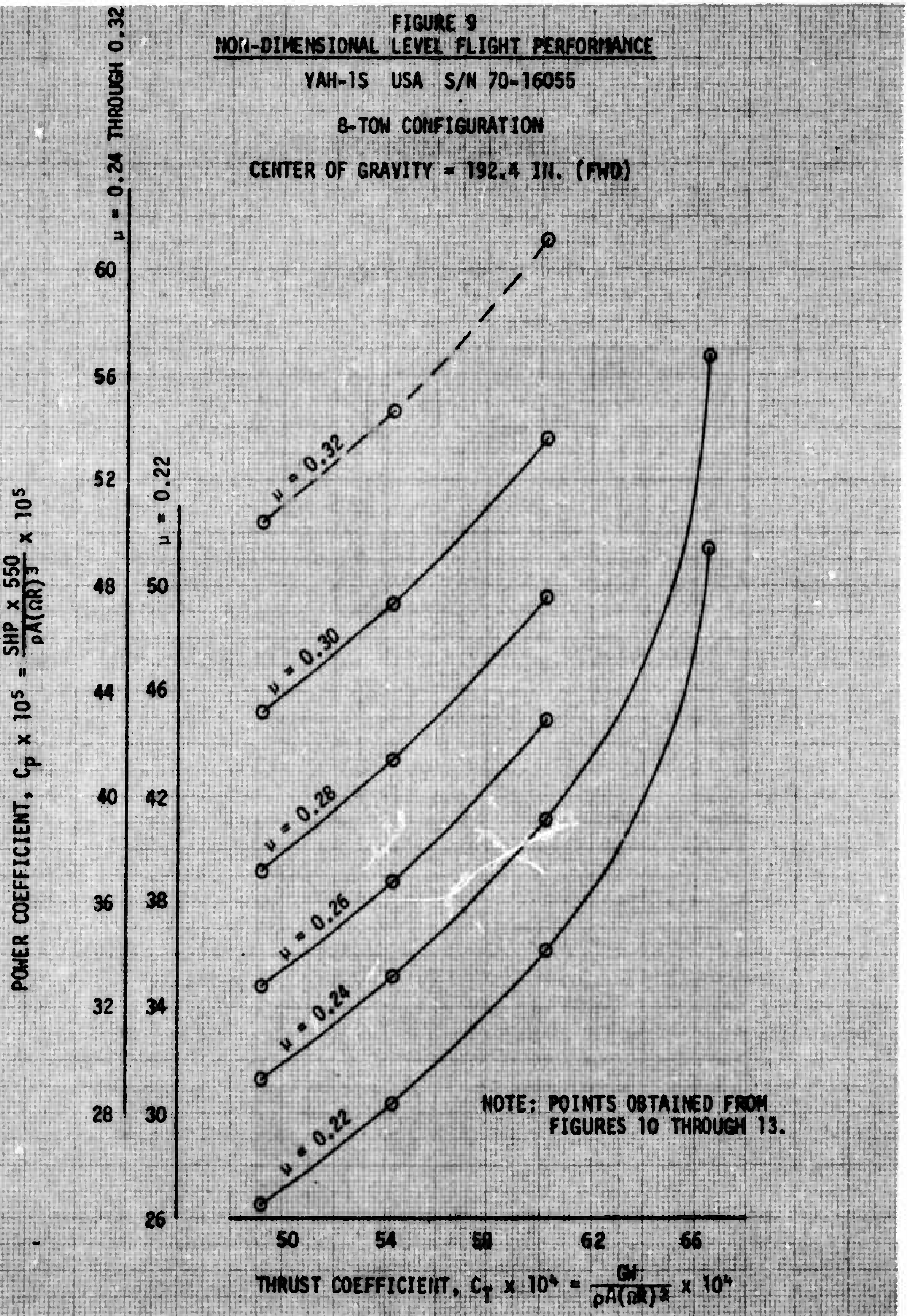


FIGURE 9
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

CENTER OF GRAVITY = 192.4 IN. (FWD)



NOTE: POINTS OBTAINED FROM FIGURES 10 THROUGH 13.

FIGURE 10
LEVEL FLIGHT PERFORMANCE
YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
8420	192.0(FWD)	5450	-6.5	324	0.004919

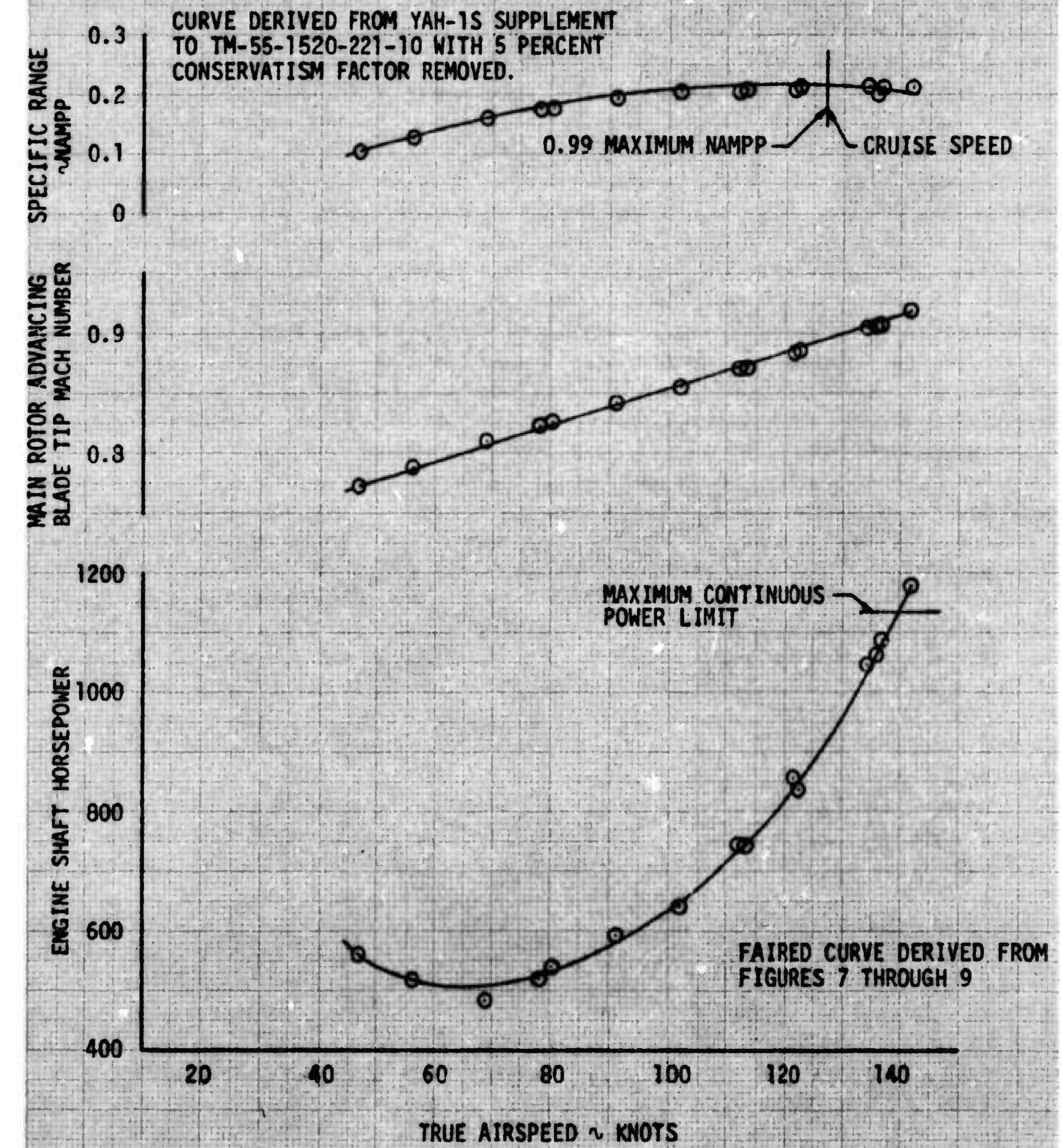


FIGURE 11

LEVEL FLIGHT PERFORMANCE

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
8740	192.0(FWD)	7440	1.5	324	0.005427

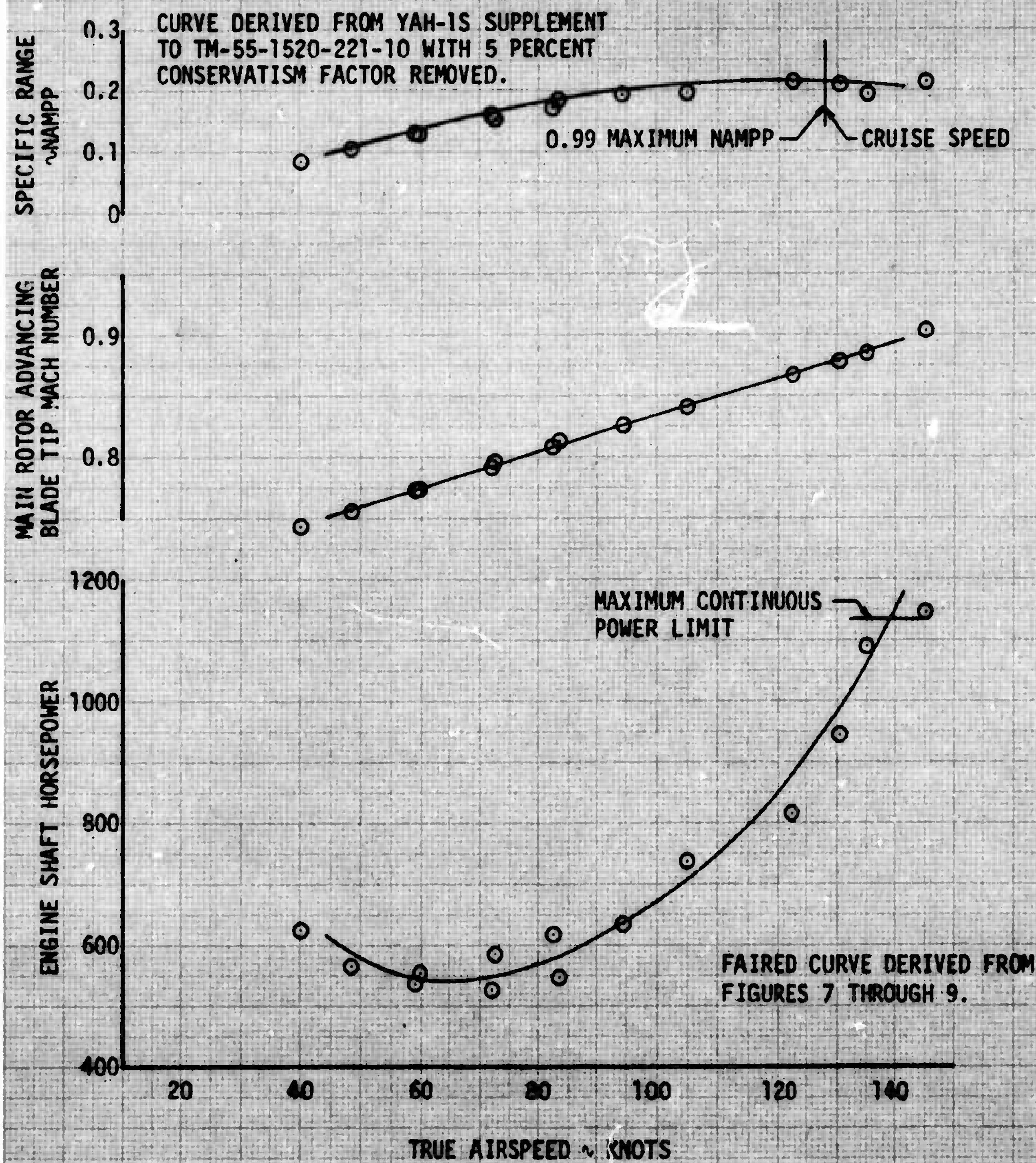


FIGURE 12
LEVEL FLIGHT PERFORMANCE
YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
9020	192.6(FWD)	9780	5.0	324	0.006024

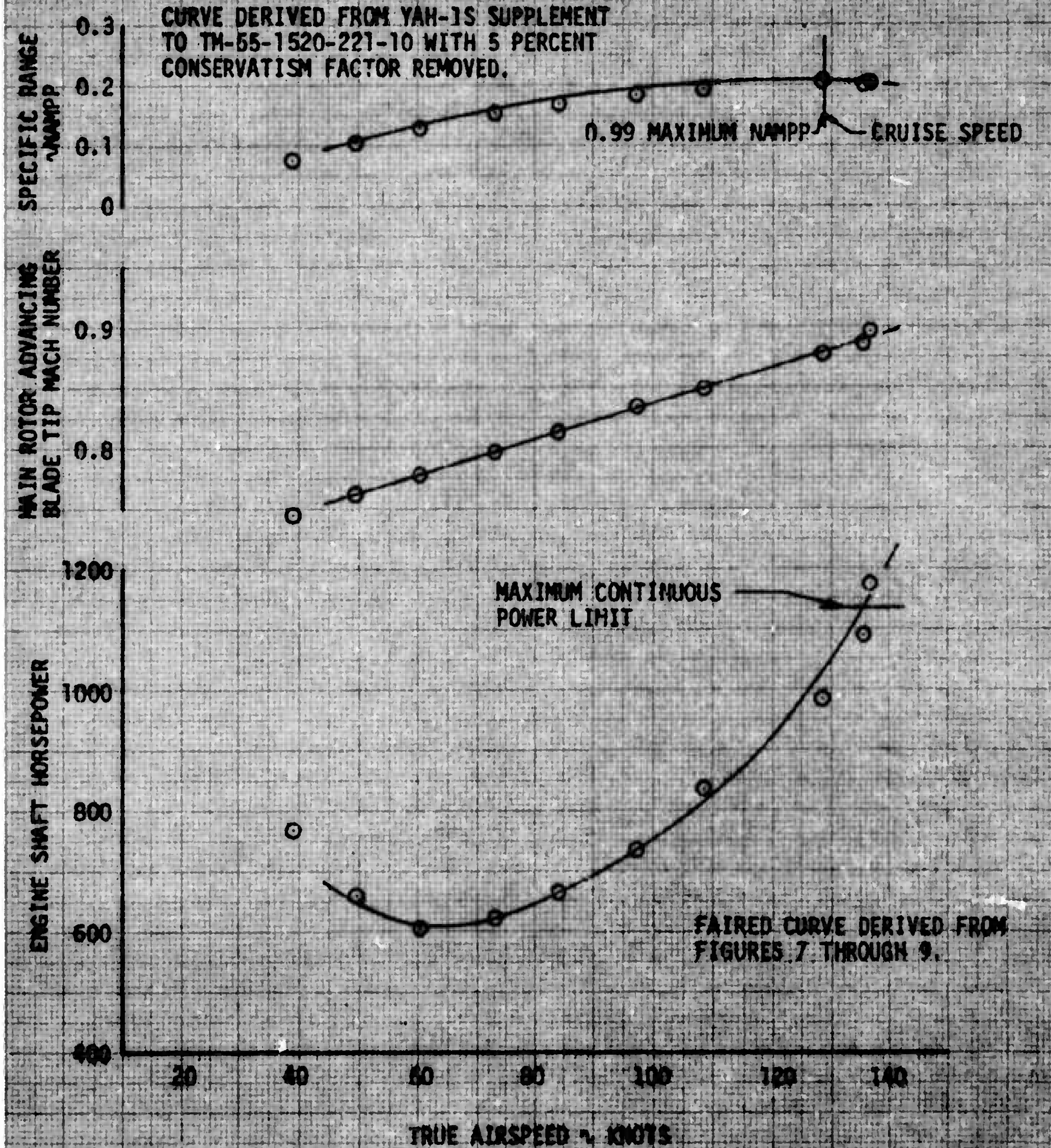


FIGURE 13
LEVEL FLIGHT PERFORMANCE
YAH-1S USA S/N 70-16065

B-TOW CONFIGURATION

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
9700	192.9(FWD)	10830	+13.0	325	0.006653

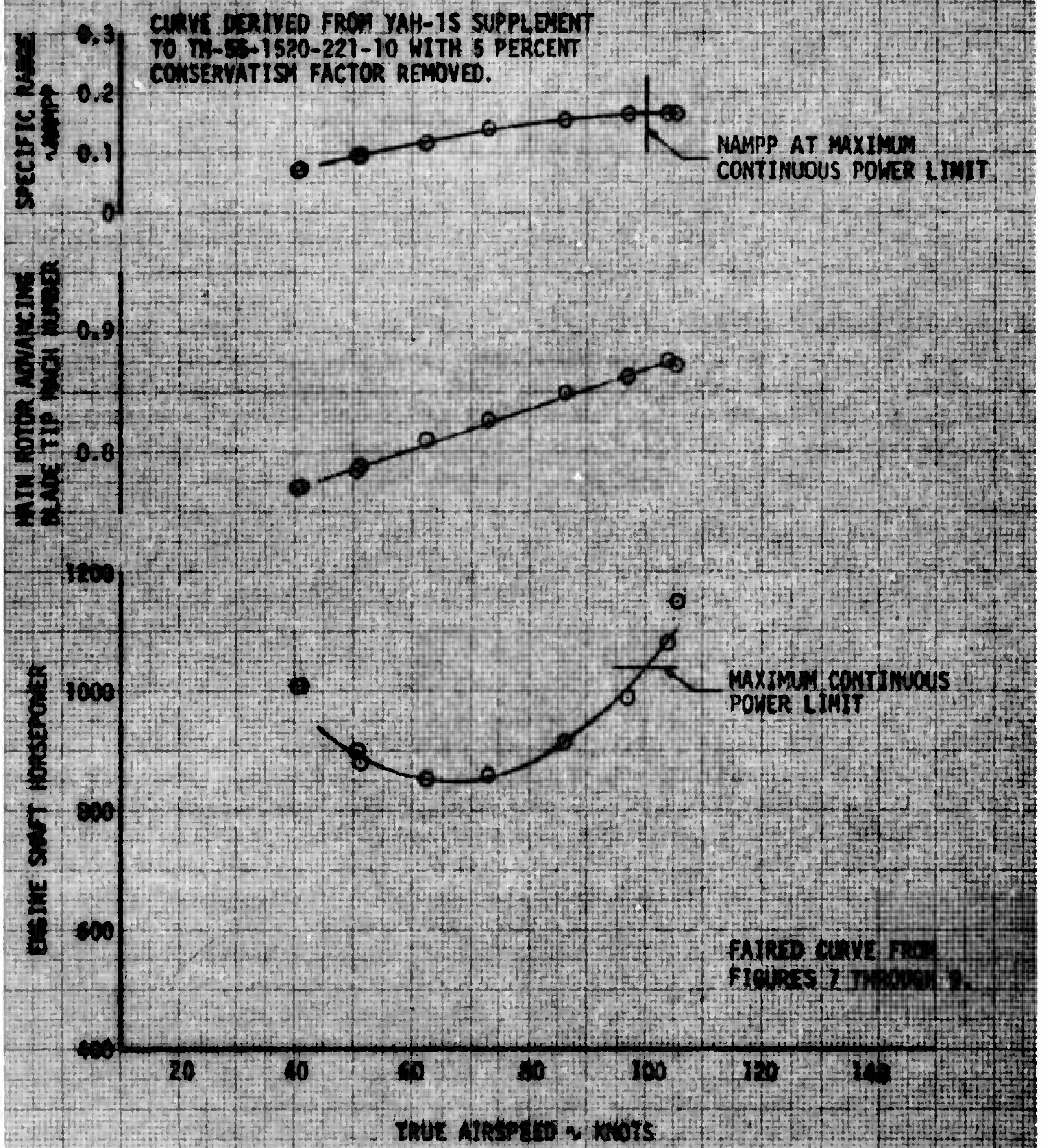


FIGURE 14
FUEL FLOW
T53-L-703 ENGINE

NOTE: CURVE DERIVED FROM YAH-1S SUPPLEMENT TO TM-55-1520-221-10, DATED 1 FEBRUARY 1975, WITH 5 PERCENT CONSERVATISM FACTOR REMOVED.

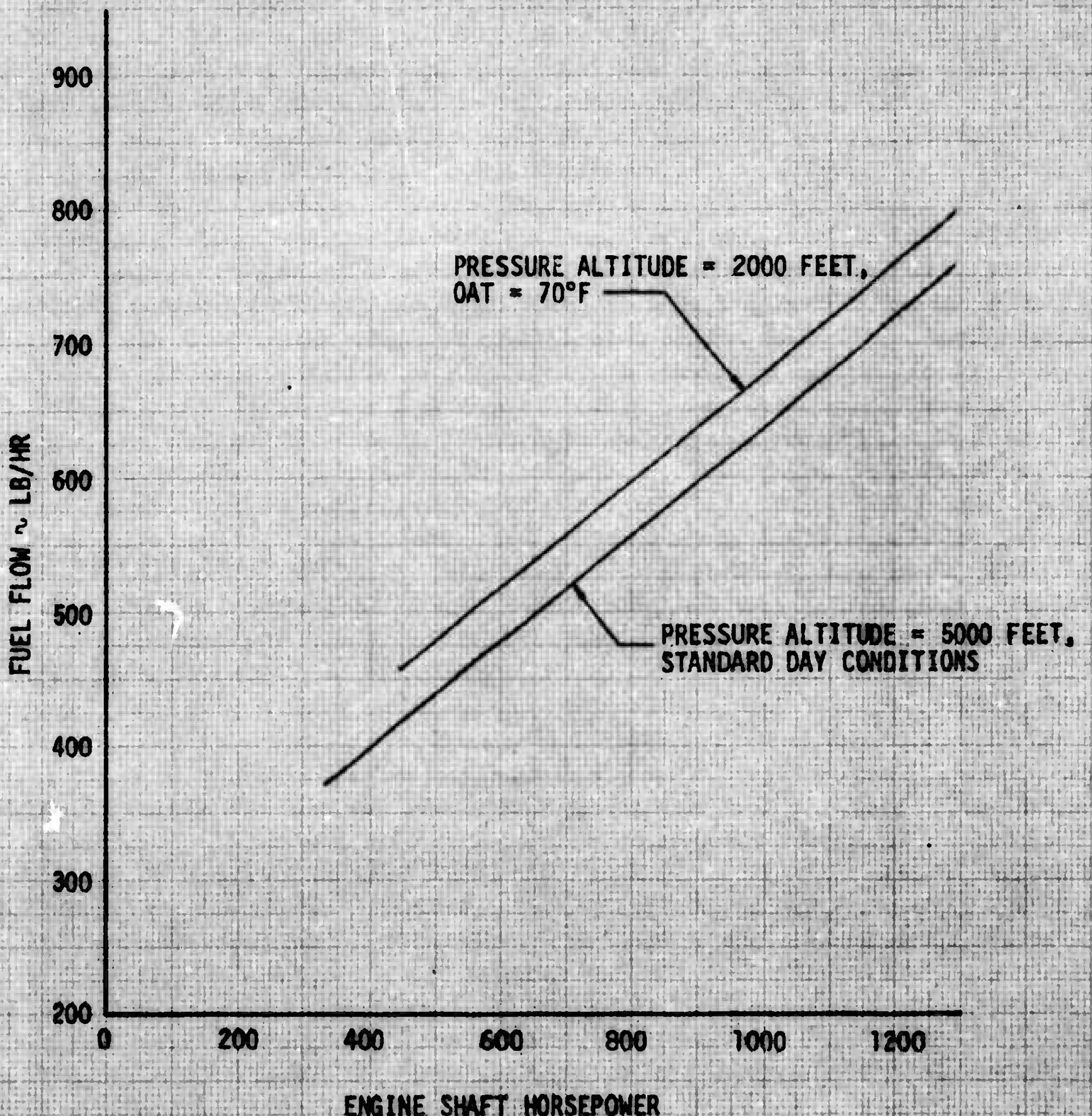


FIGURE 15

LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS

YAH-1S USA S/N 70-16055

NOTES:
1. ROTOR STATIC.
2. CYCLIC FRICTION AT MANUFACTURER'S PRE-SET VALUE.
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
4. HYDRAULIC BOOST SYSTEMS ON.
5. LATERAL CONTROL POSITION CENTERED.
6. SHADED SYMBOLS DENOTE TRIM POSITIONS.
7. CONTROL FORCES MEASURED AT CENTER OF GRIP.
8. FORCE TRIM ON.

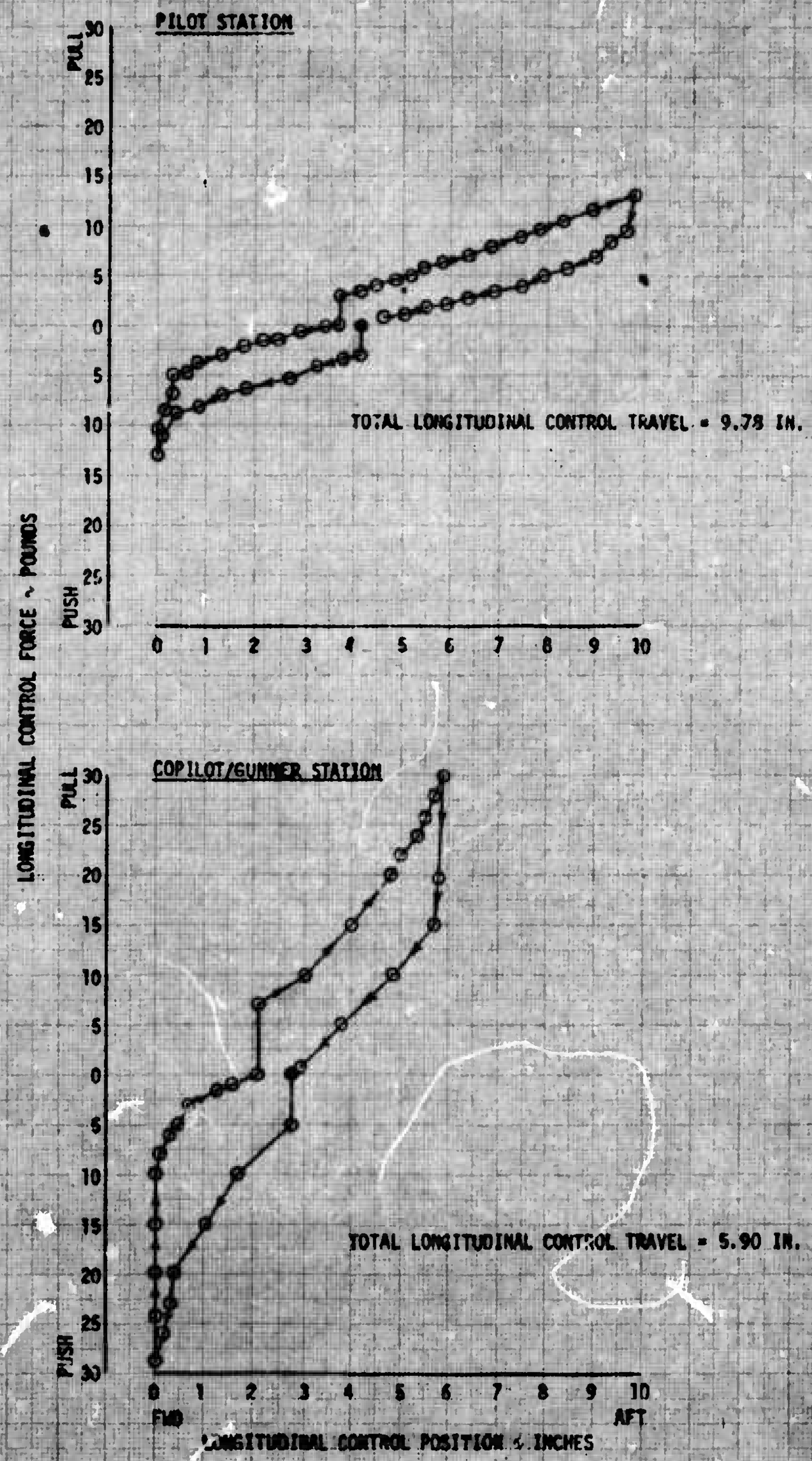


FIGURE 16

LATERAL CONTROL SYSTEM CHARACTERISTICS

YAH-15 USA S/N 70-16056

NOTES:
1) ROTOR STATIC.
2) CYCLIC FRICTION AT MANUFACTURER'S PRE-SET VALUE.
3) HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
4) HYDRAULIC BOOST SYSTEMS ON.
5) LONGITUDINAL CONTROL POSITION CENTERED.
6) SHADED SYMBOLS DENOTE TRIM POSITIONS.
7) CONTROL FORCES MEASURED AT CENTER OF GRIP.
8) FORCE TRIM ON.

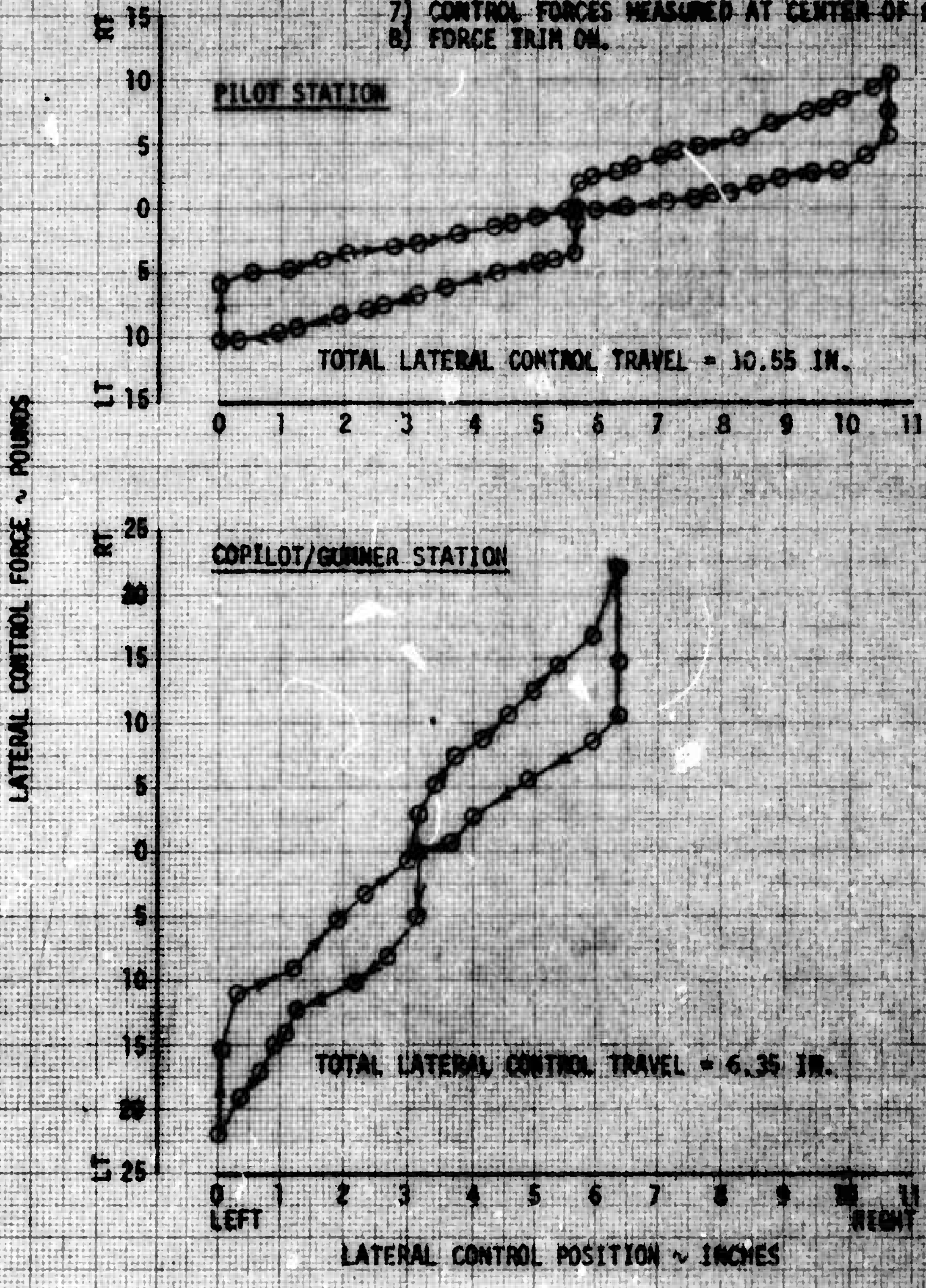


FIGURE 17
DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS
YAH-1S USA S/N 70-16065

NOTES:
1) ROTOR STATIC.
2) HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNITS.
3) CYCLIC CONTROL CENTERED.
4) SHADED SYMBOL DENOTES TRIM POSITION.
5) CONTROL FORCES MEASURED AT CENTER OF PEDAL.
6) FORCE TRIM ON.

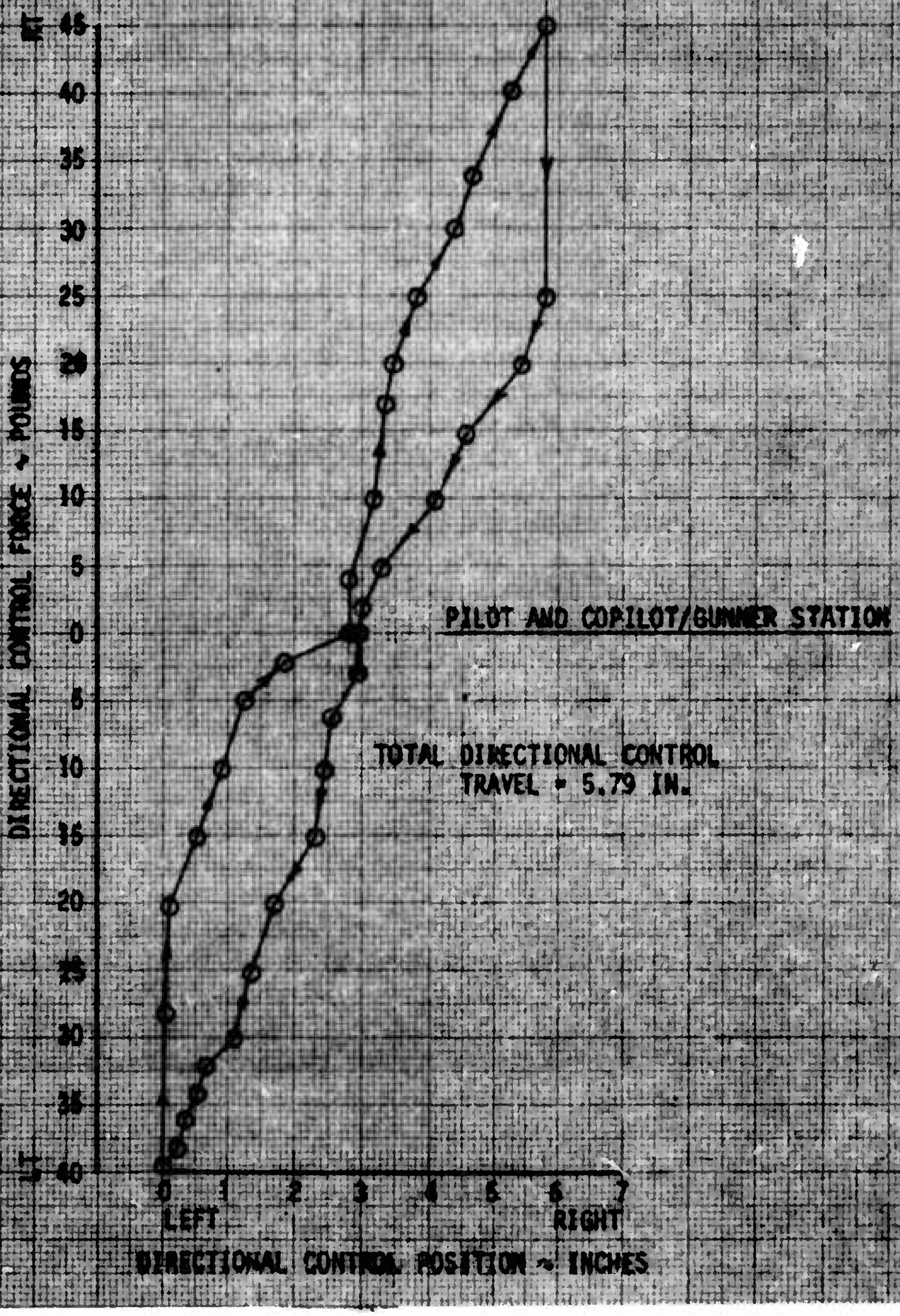


FIGURE 18
COLLECTIVE CONTROL SYSTEM CHARACTERISTICS

YAH-1S USA S/N 70-16055

NOTES:
1. ROTOR STATIC.
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND UNIT.
3. HYDRAULIC BOOST SYSTEMS ON.
4. CYCLIC CONTROL CENTERED.
5. CONTROL FORCES MEASURED AT CENTER OF GRIP.

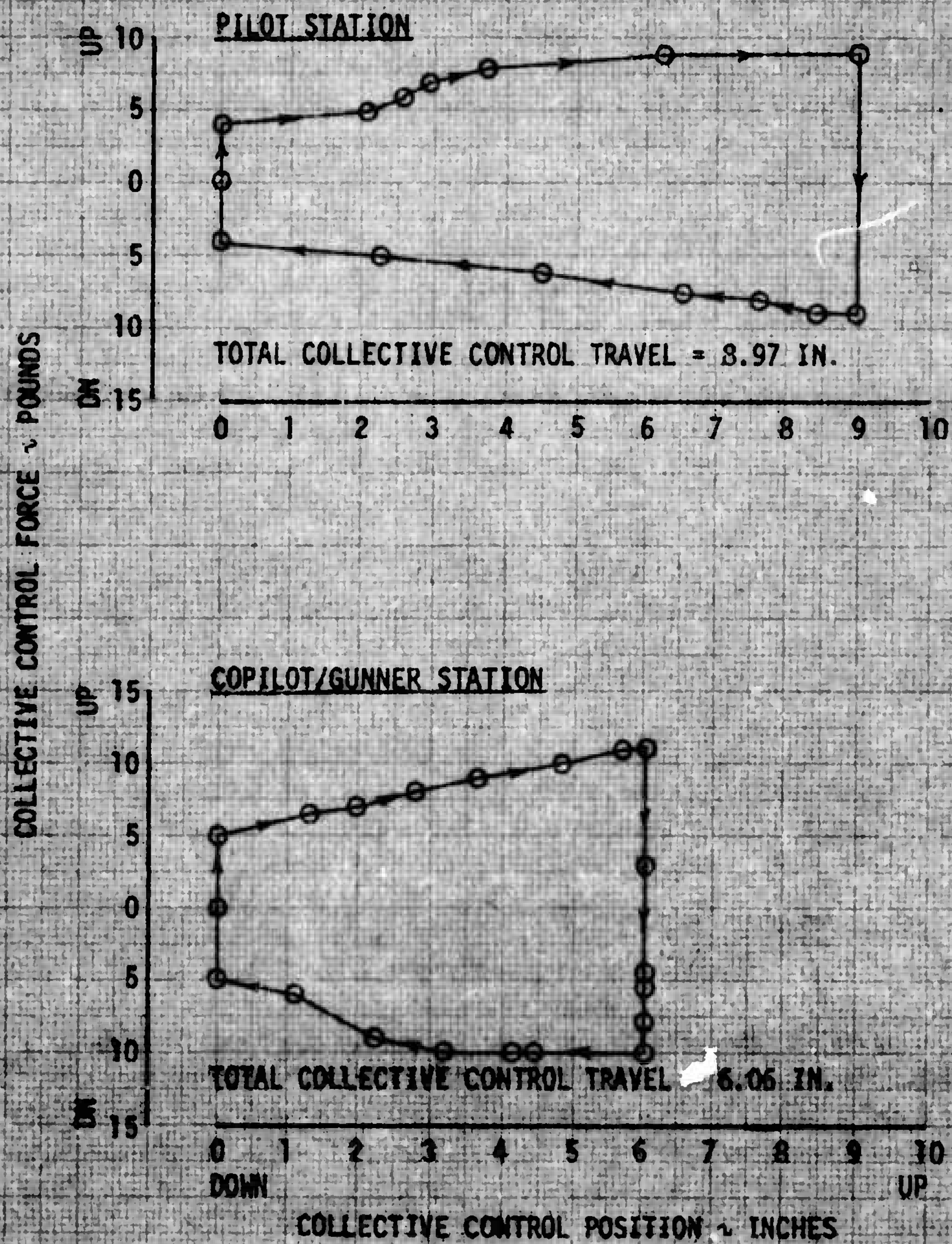


FIGURE 39
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

SYMBOL	FLIGHT CONDITION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
⊙	LEVEL	8140	192.0(FWD)	5600	-7.0	325	0.008749
◇	LEVEL	9640	192.9(FWD)	10960	-13.0	325	0.006518

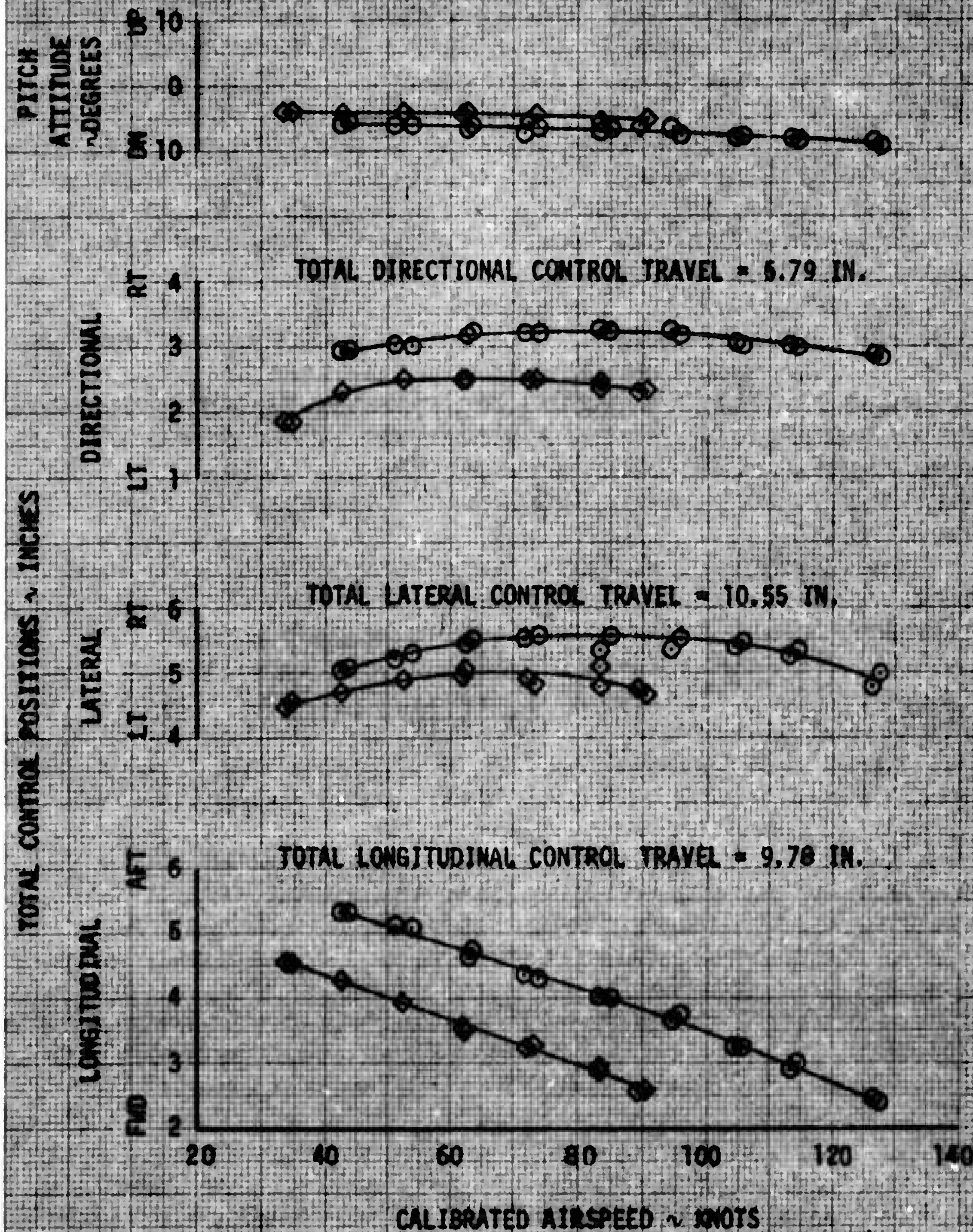


FIGURE 20
LONGITUDINAL CONTROLLABILITY
YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

SCAS CONDITION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
ON	8800	192.2(FWD)	9600	-8.5	324	0.005845

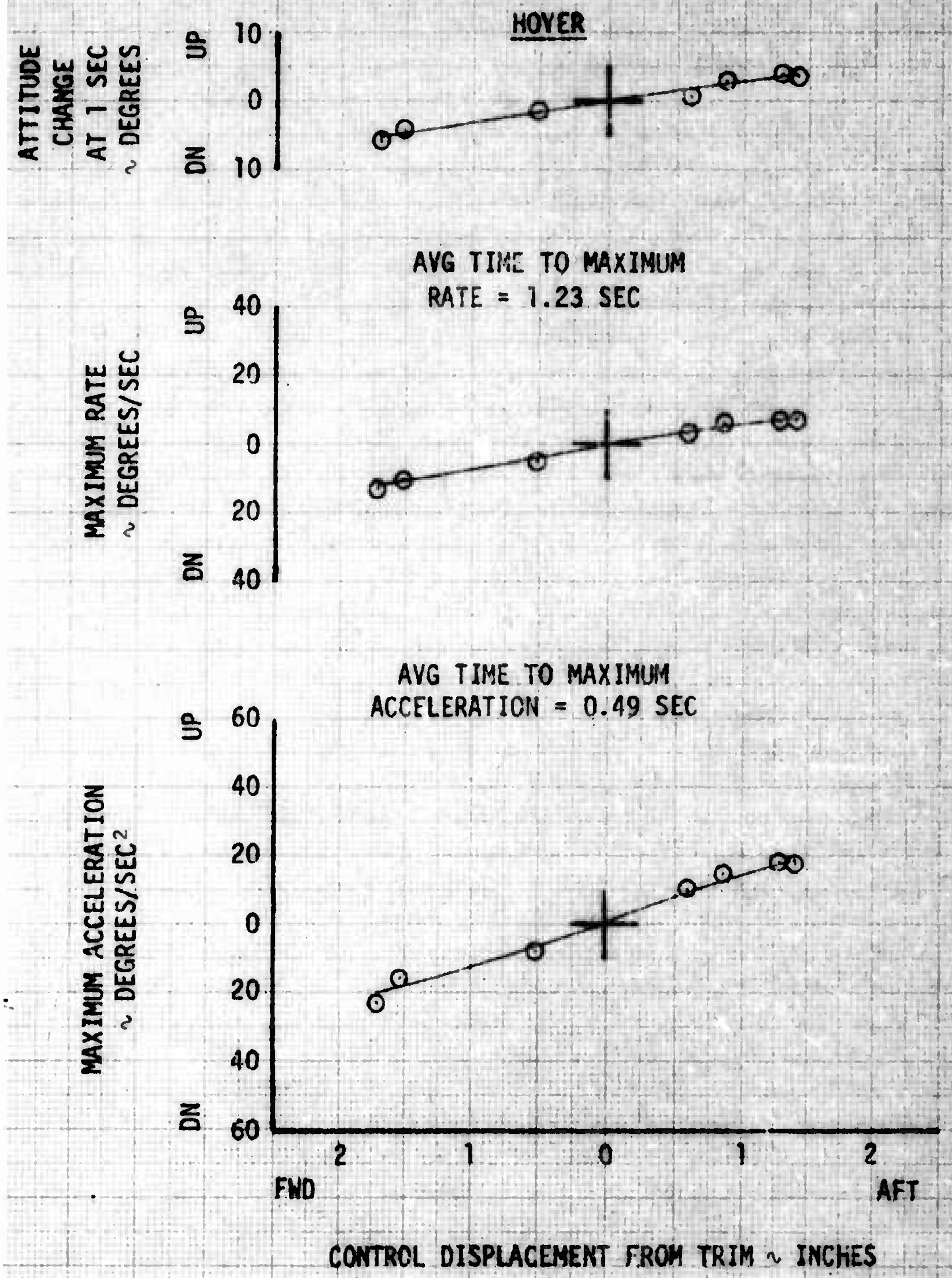


FIGURE 21
LONGITUDINAL CONTROLLABILITY
YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

SCAS CONDITION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
ON	8640	191.9(FWD)	10220	-5.0	325	0.005815

REARWARD FLIGHT ~ 37 KTAS

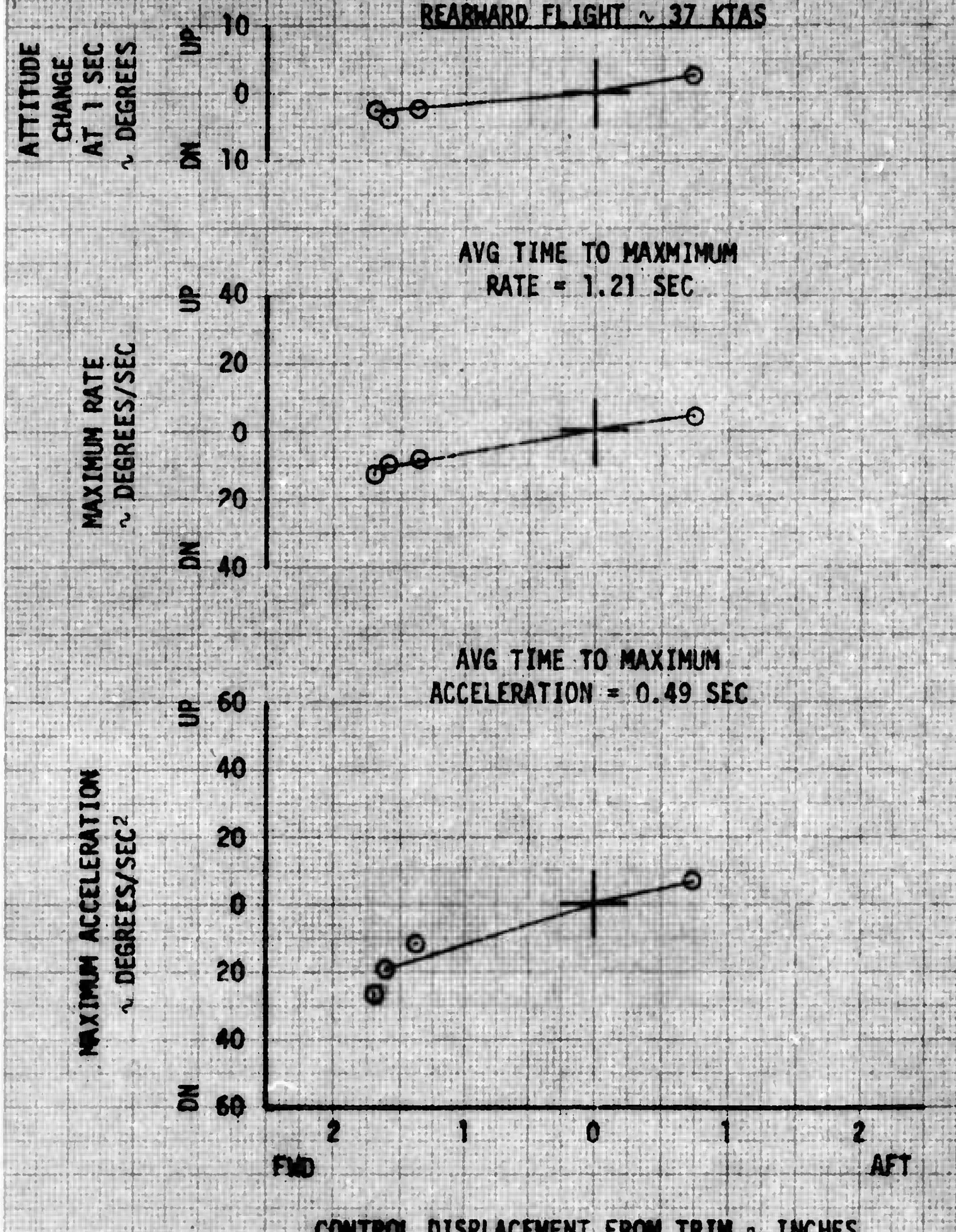


FIGURE 22

LATERAL CONTROLLABILITY

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

SCAS CONDITION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
ON	8760	192.2(FWD)	9700	-8.0	324	0.005836

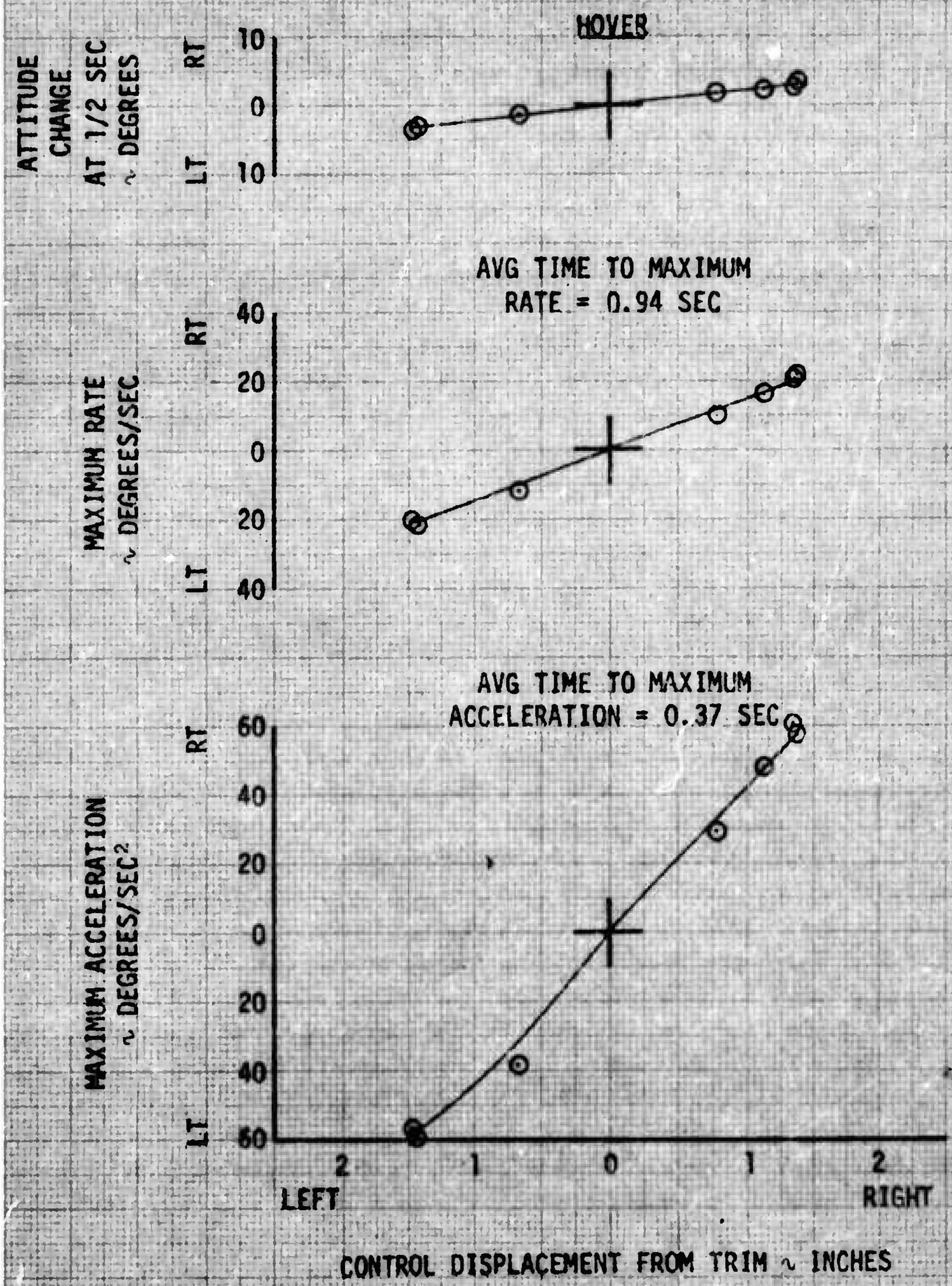


FIGURE 23
LATERAL CONTROLLABILITY
YAH-1S USA S/N 70-16056
8-TOW CONFIGURATION

SYMBOL	SCAS CONDITION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
○	ON	8800	192.3(FWD)	9820	-8.0	325	0.006067
◇	ON	8560	191.8(FWD)	10520	-8.0	325	0.005816

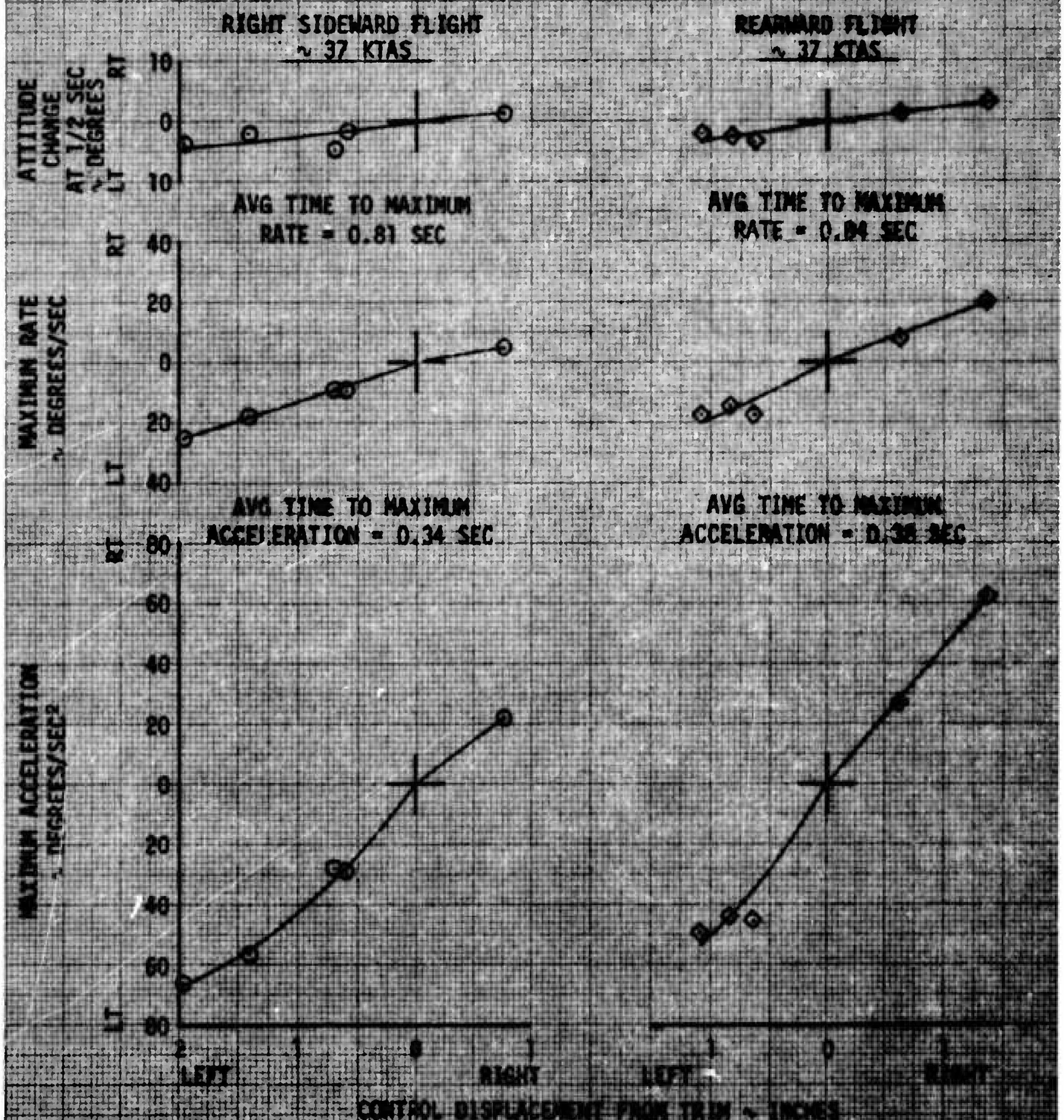


FIGURE 24

DIRECTIONAL CONTROLLABILITY

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

SYMBOL	SCAS CONDITION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
○	ON	8720	192.2(FWD)	9600	-8.5	325	0.005756
□	OFF	8640	192.1(FWD)	9600	-8.5	325	0.005703
△	ON	9200	192.8(FWD)	9400	-10.0	324	0.006072
◇	OFF	9060	192.6(FWD)	9660	-9.5	324	0.006030

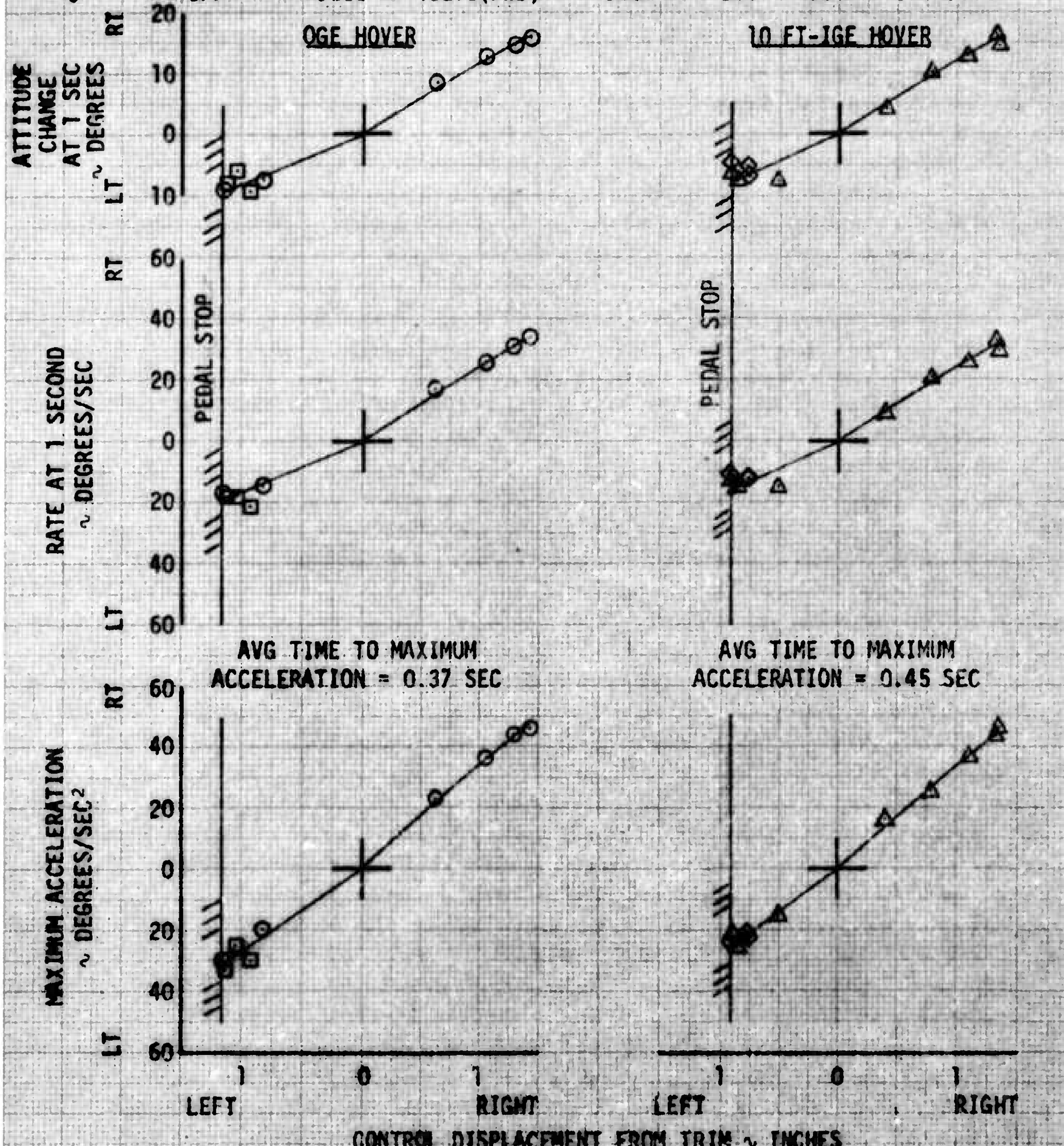


FIGURE 25
DIRECTIONAL CONTROLLABILITY
YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

SCAS CONDITION	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
ON	8660	192.2(FWD)	10100	-6.0	325	0.005807

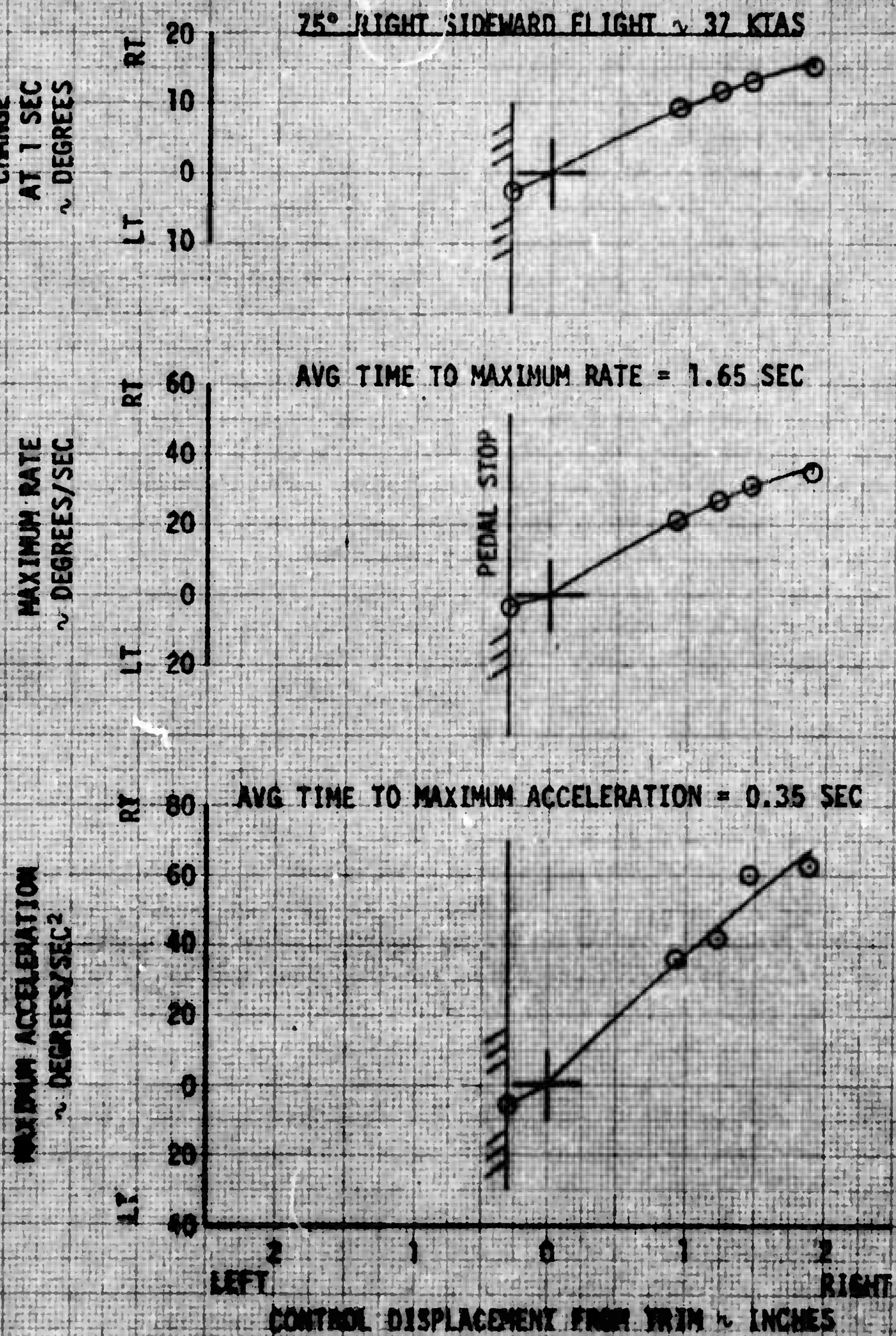
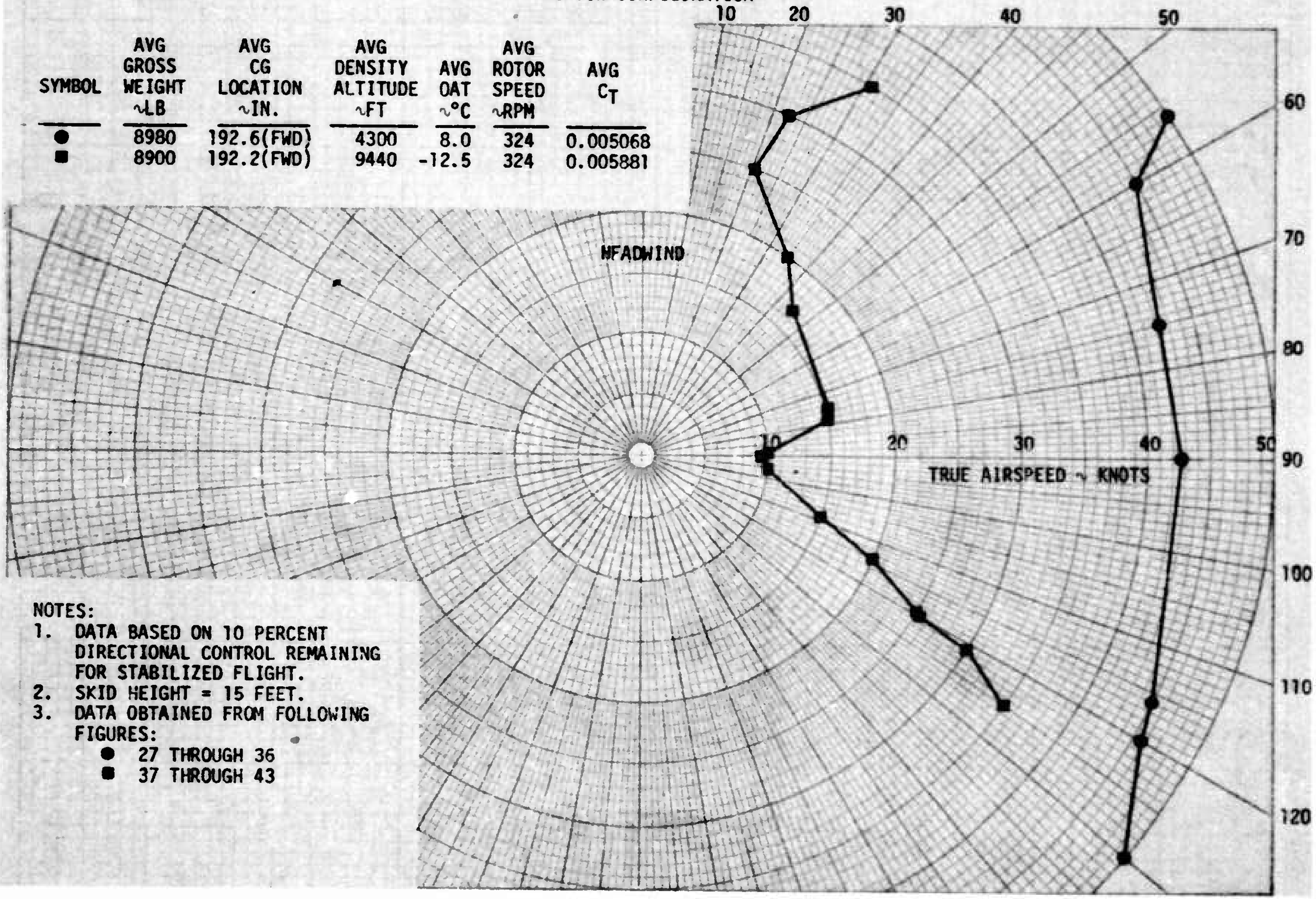


FIGURE 26
DIRECTIONAL CONTROL SUMMARY
YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

SYMBOL	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
●	8980	192.6(FWD)	4300	8.0	324	0.005068
■	8900	192.2(FWD)	9440	-12.5	324	0.005881



NOTES:
1. DATA BASED ON 10 PERCENT DIRECTIONAL CONTROL REMAINING FOR STABILIZED FLIGHT.
2. SKID HEIGHT = 15 FEET.
3. DATA OBTAINED FROM FOLLOWING FIGURES:
   - ● 27 THROUGH 36
   - ■ 37 THROUGH 43

FIGURE 27

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

O-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
5	9020	192.6(FWD)	4220	7.5	323	0.005109

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

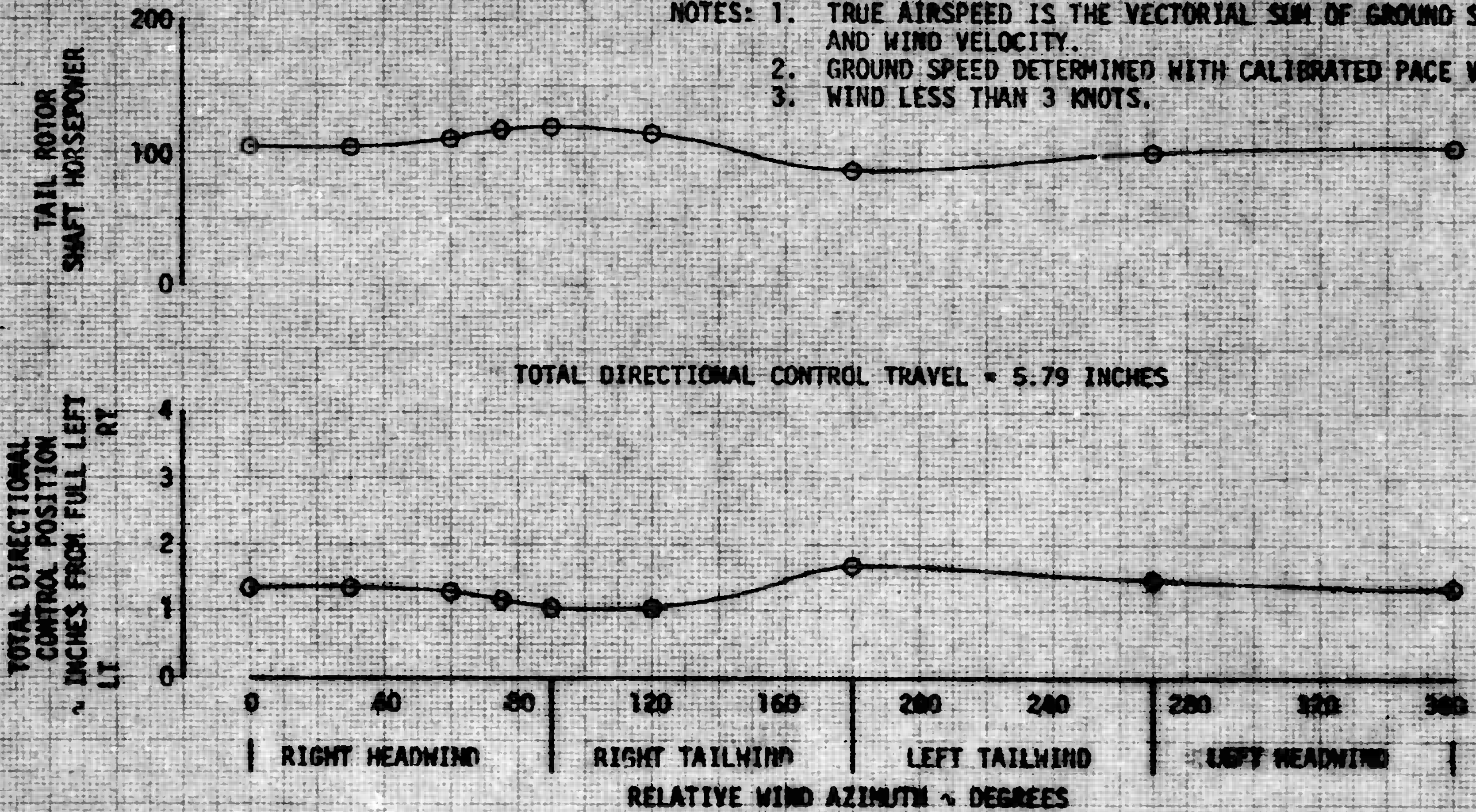


FIGURE 28

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
10	9000	192.6(FWD)	4260	7.5	323	0.005103

NOTES:
1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

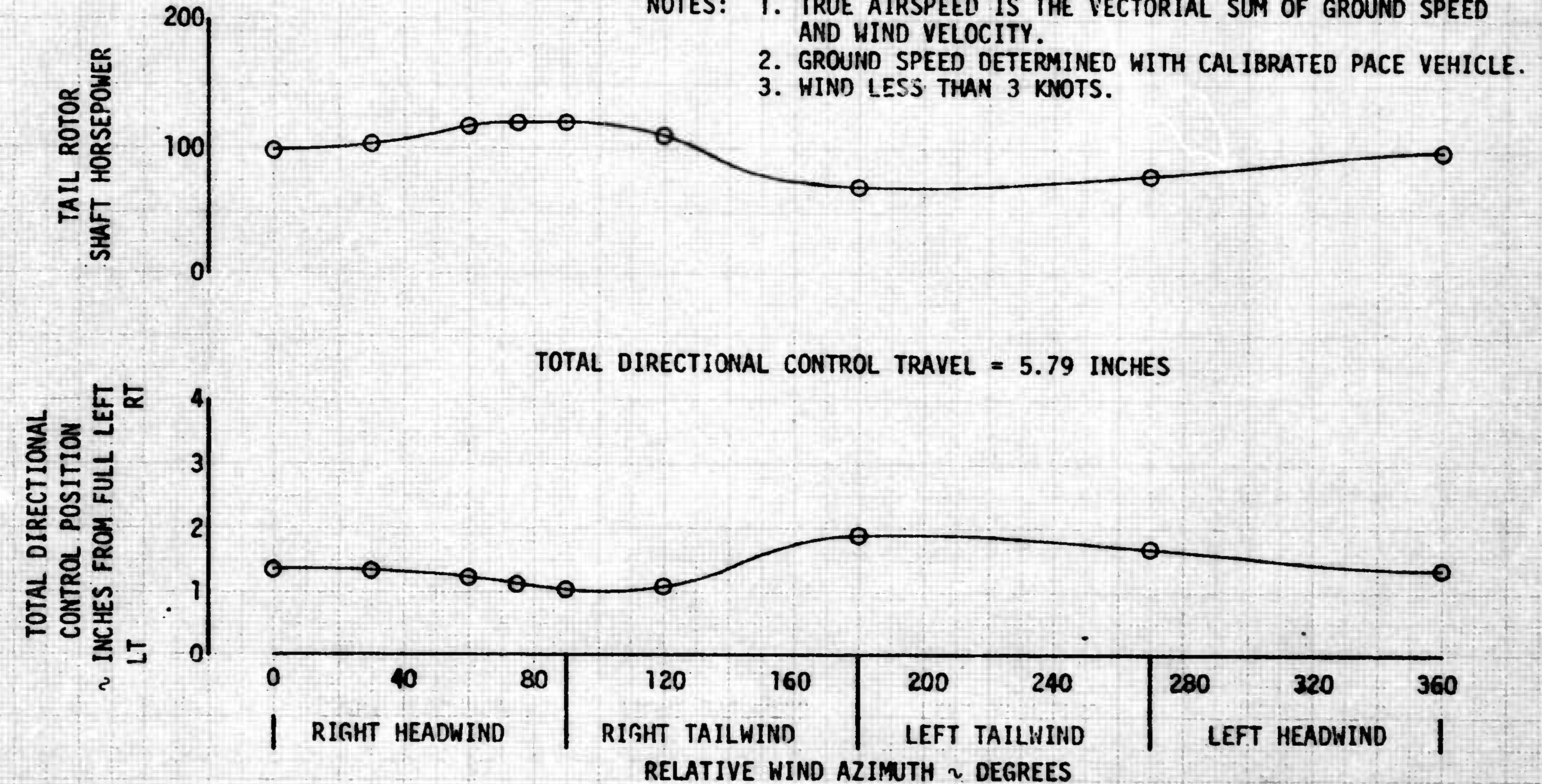


FIGURE 29
DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTH

YAH-1S USA S/N 70-16055
8-TON CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
15	9000	192.6(FWD)	4240	7.5	324	0.005069

NOTES:
1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

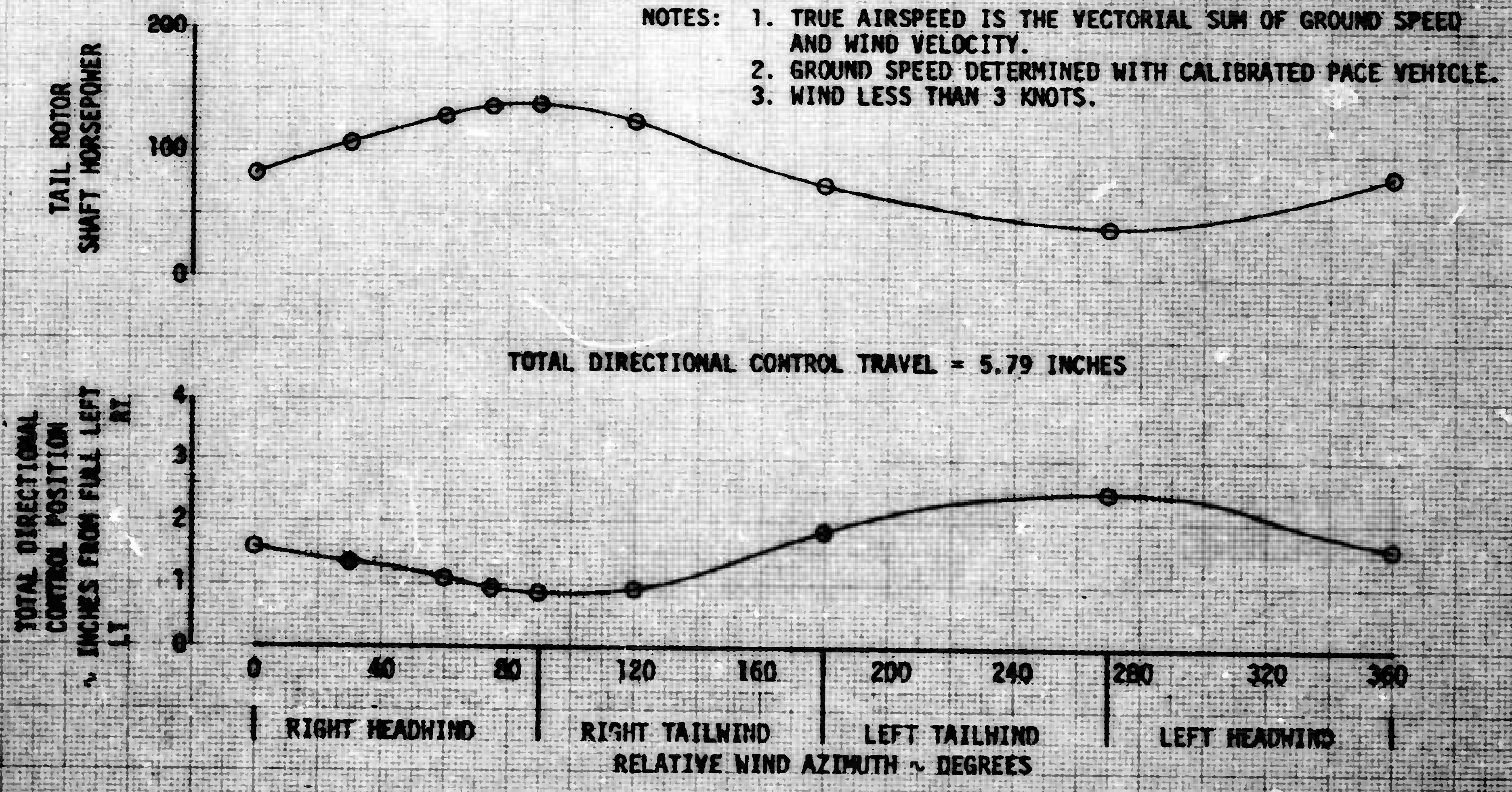


FIGURE 30
DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
20	8980	192.6(FWD)	4240	7.5	324	0.005058

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

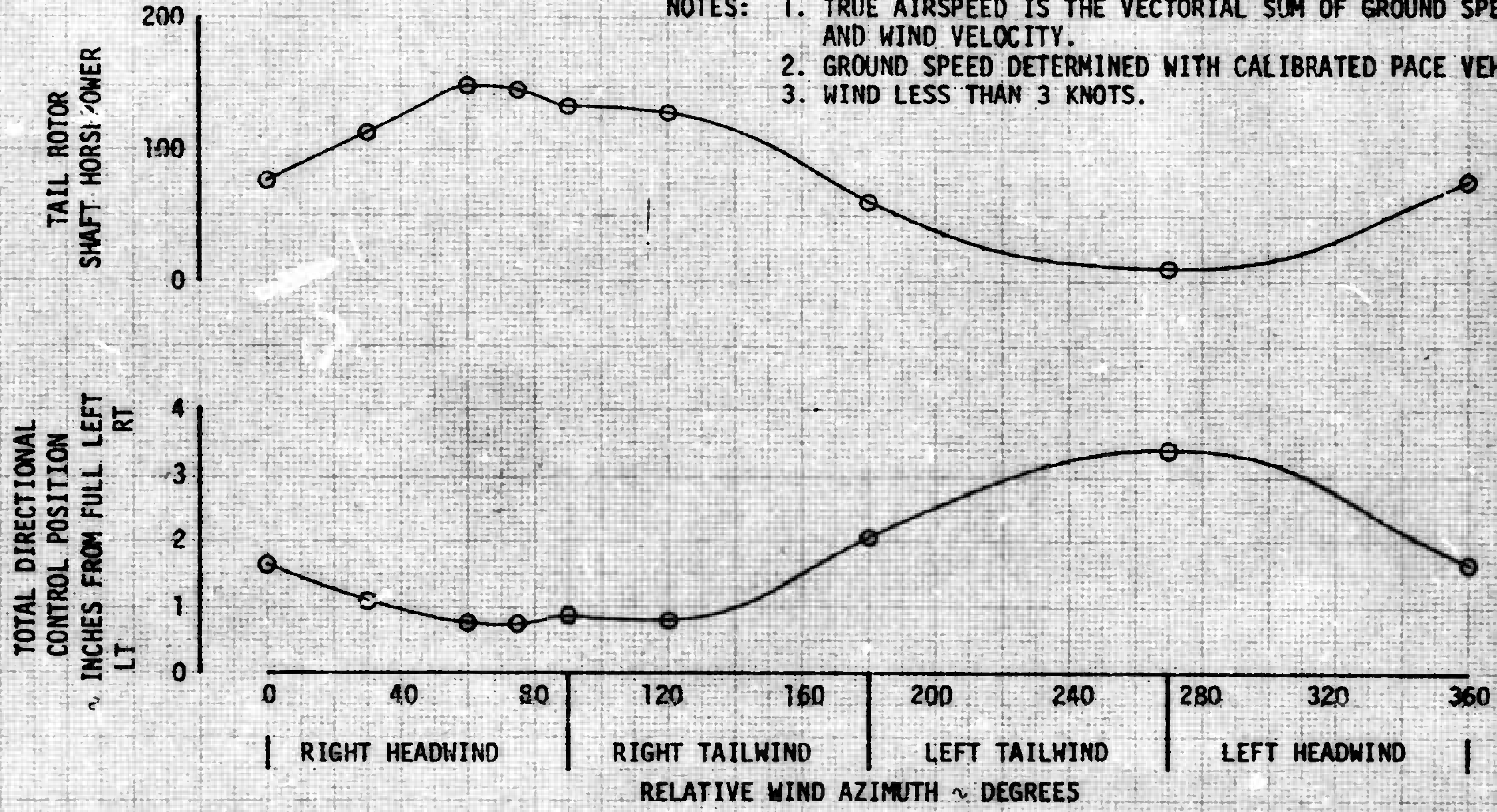


FIGURE 31

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

B-YOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
25	8960	192.6(FWD)	4880	8.0	324	0.005053

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

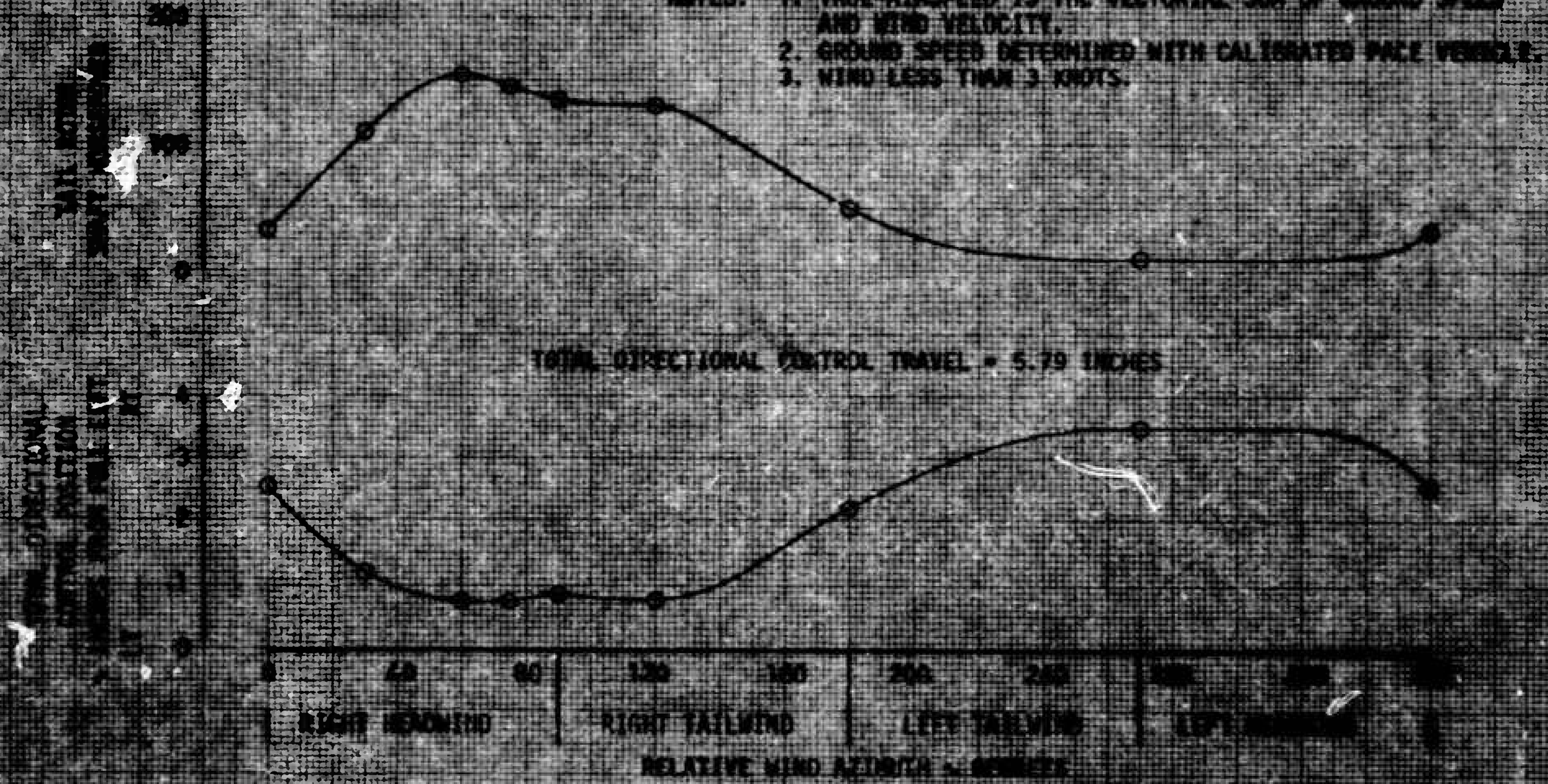


FIGURE 32

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
30	9000	192.6(FWD)	4300	8.0	325	0.005047

NOTES:
1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

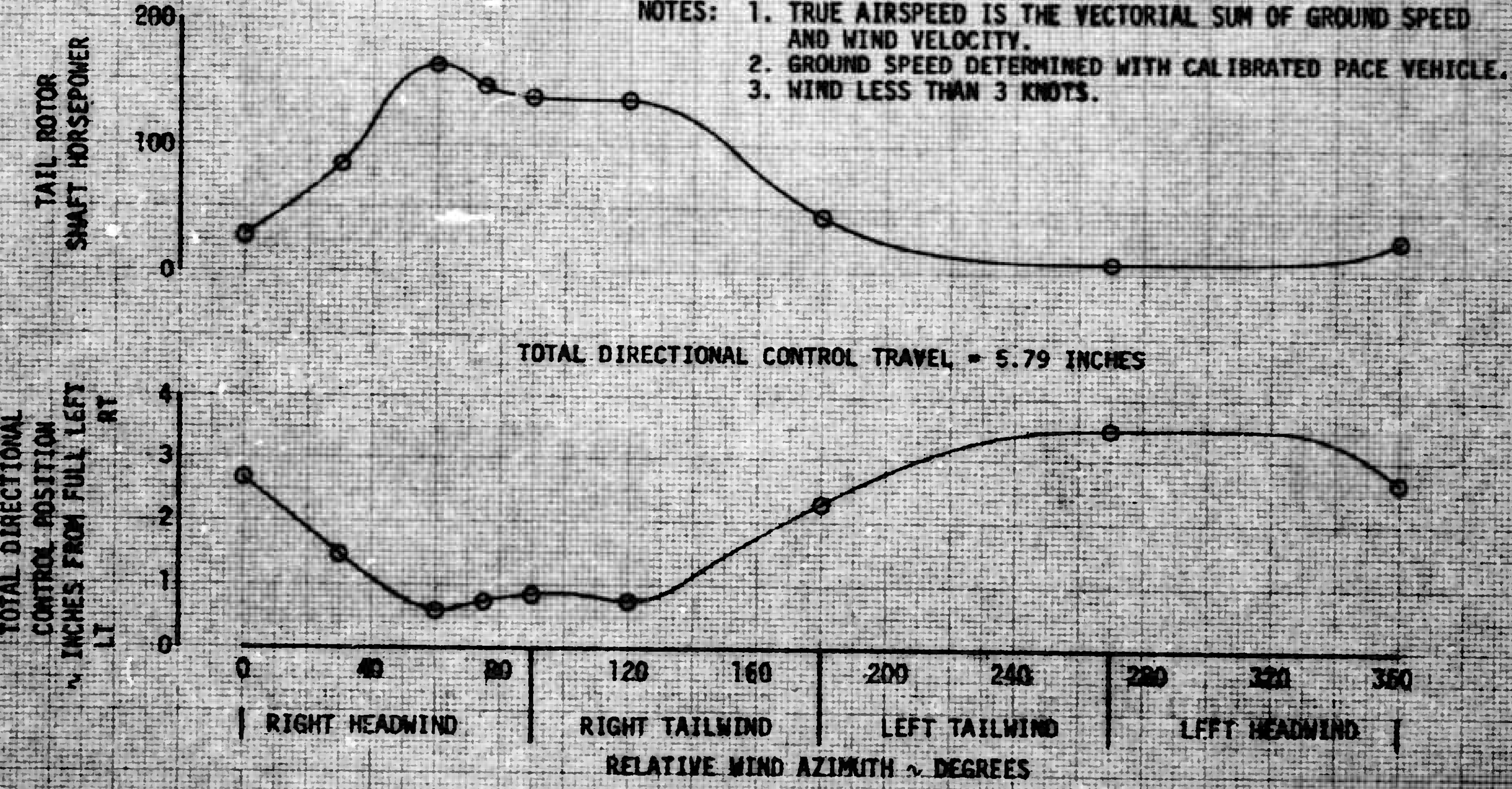


FIGURE 33

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
35	8980	192.6(FWD)	4300	8.0	324	0.005067

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

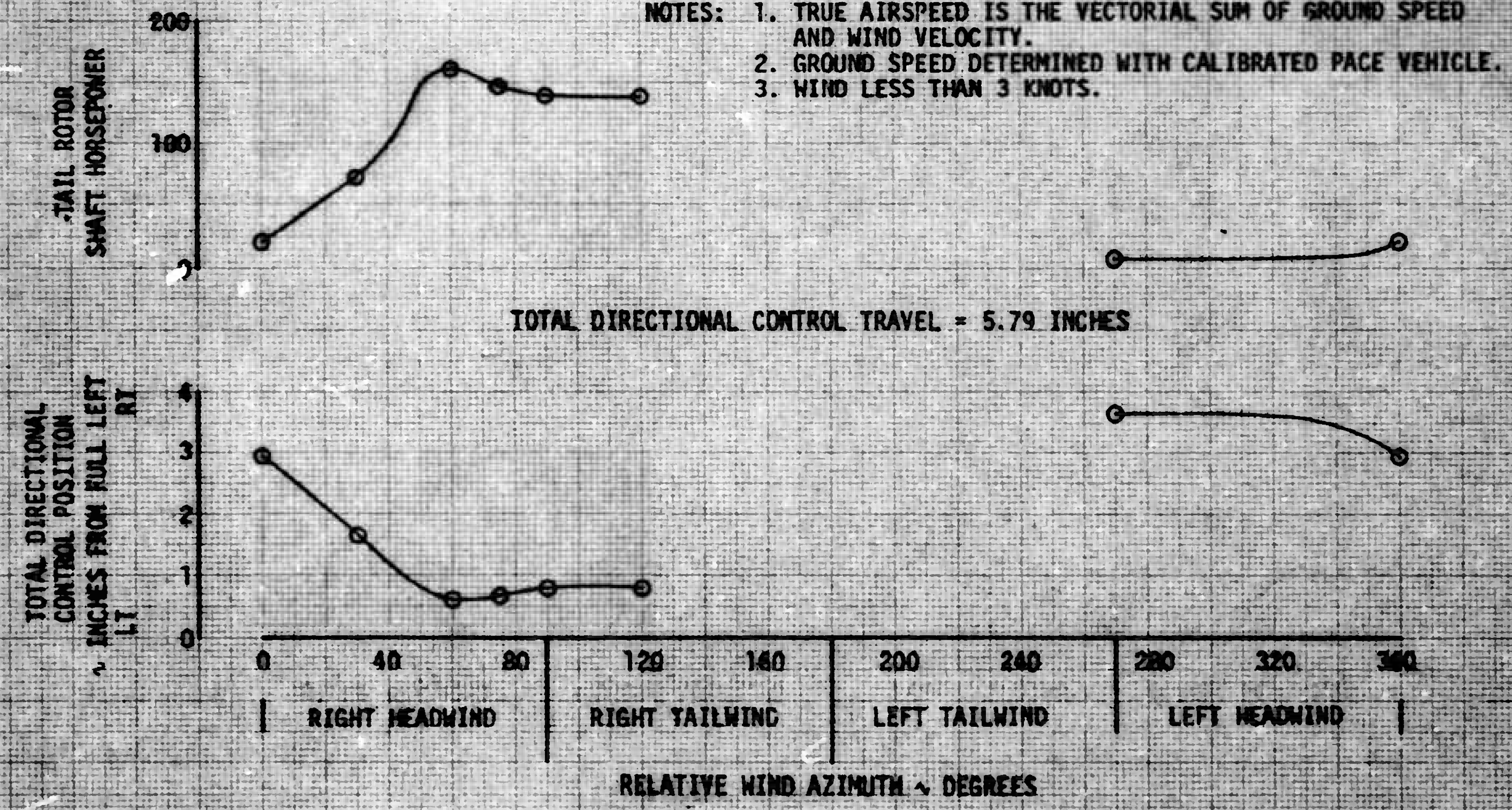


FIGURE 34

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
40	8980	192.6(FWD)	4300	8.0	325	0.006036

NOTES:
1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AD WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

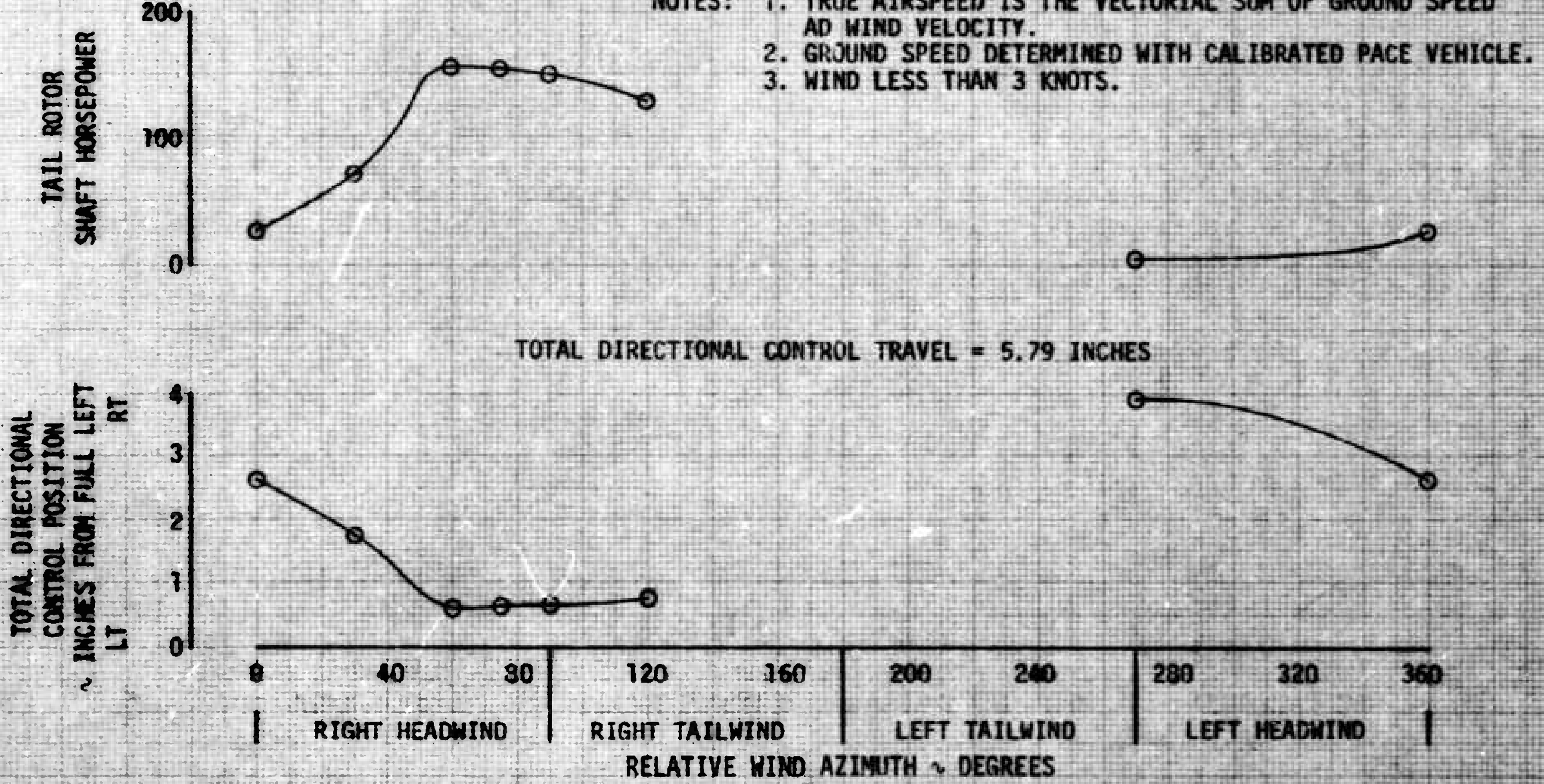


FIGURE 35
DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
45	8960	192.5(FWD)	4300	8.0	325	0.005025

NOTES:
1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

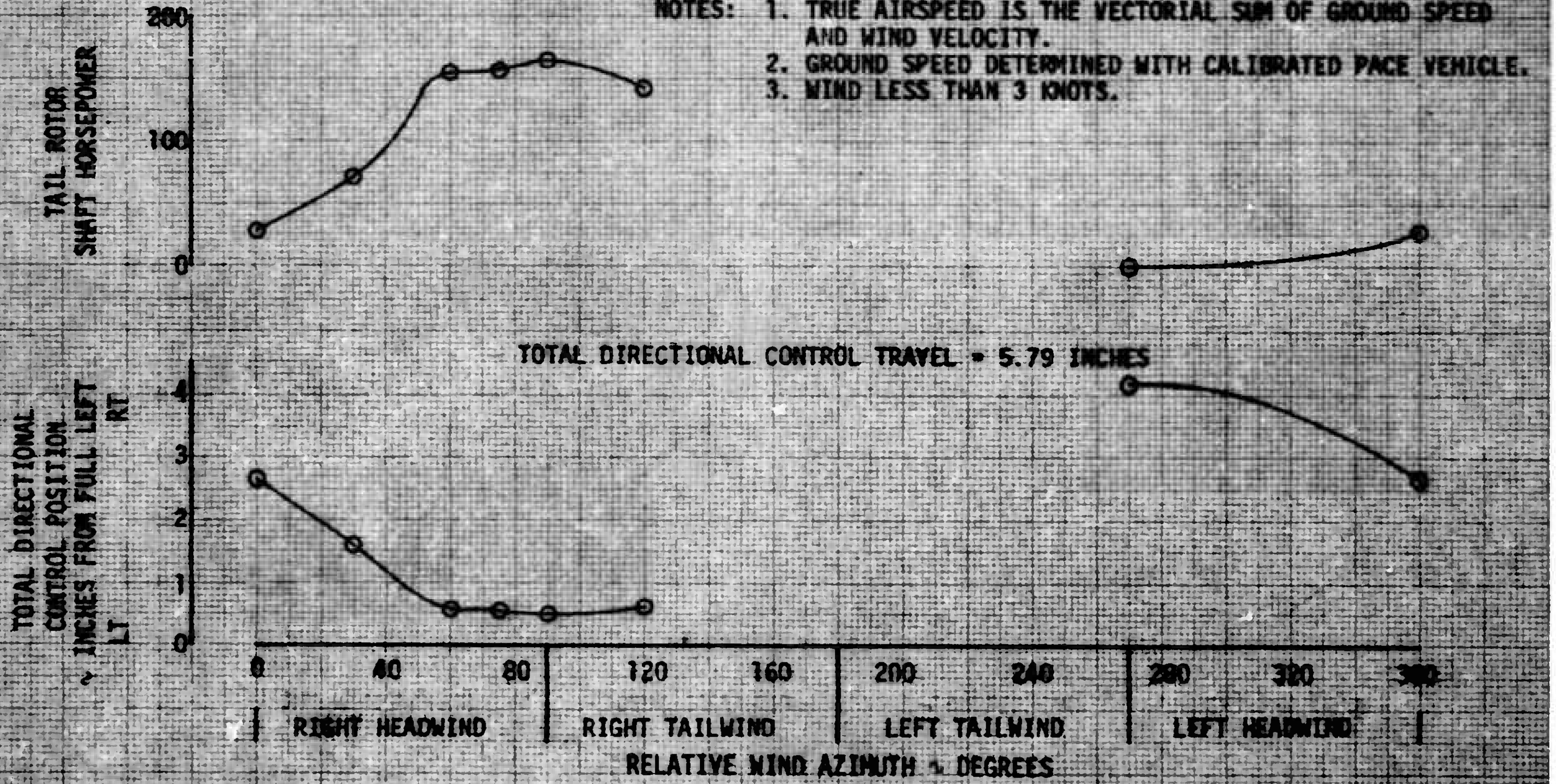


FIGURE 36

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
50	8940	192.5(FWD)	4340	8.0	325	0.005019

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

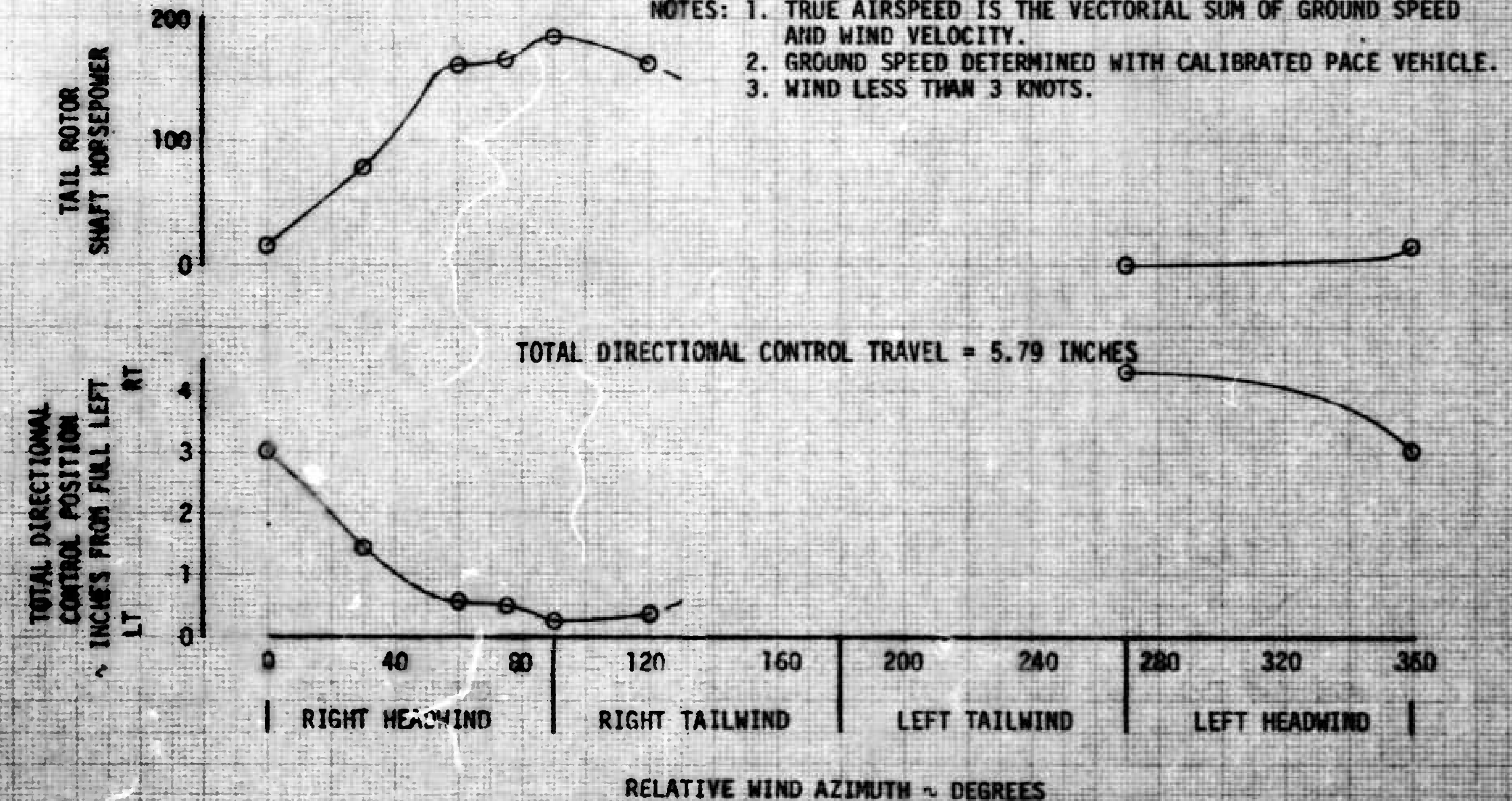


FIGURE 37

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
5	8920	192.2(FWD)	9340	-13.0	323	0.005911

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

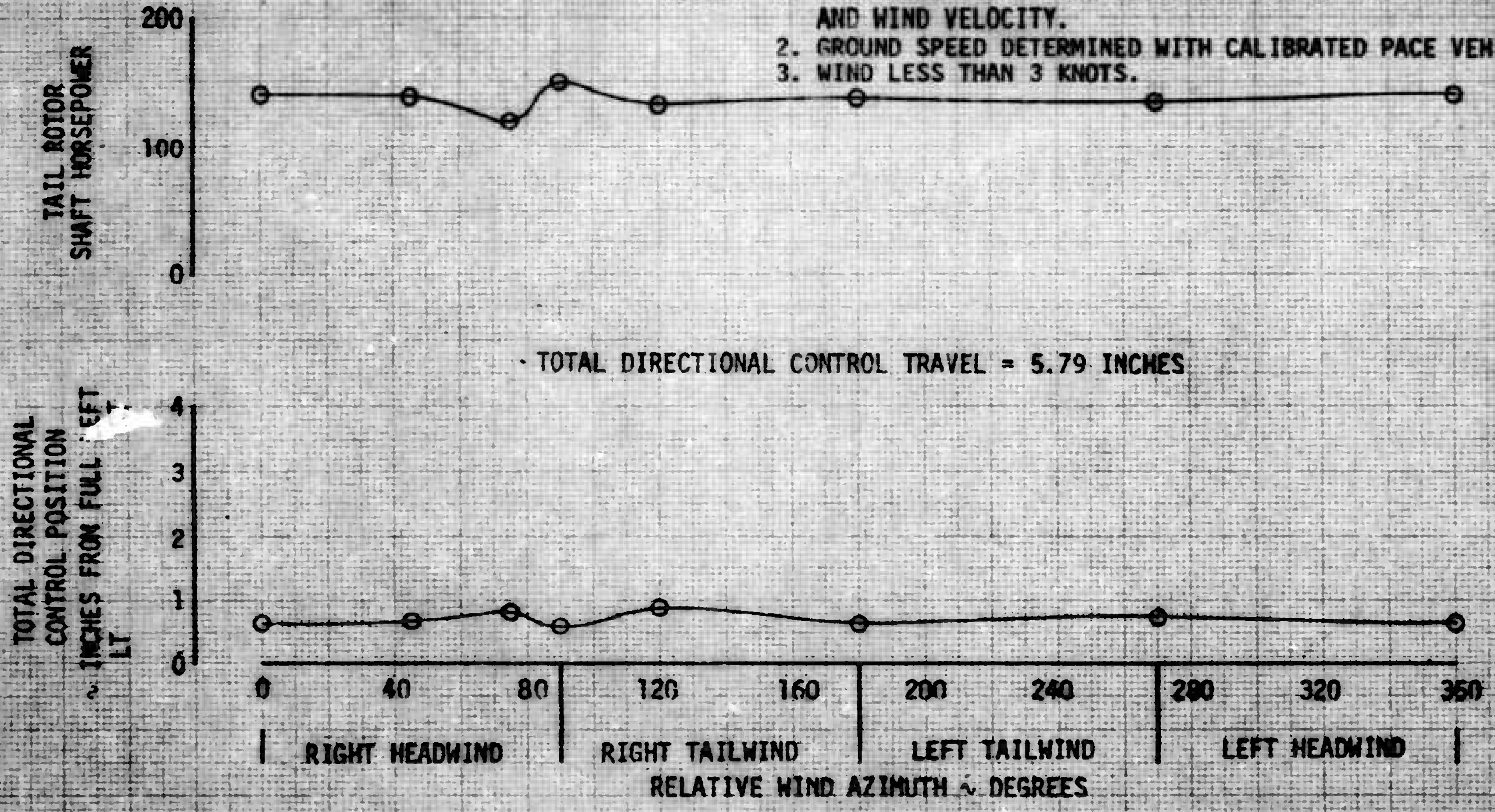


FIGURE 38

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
10	8900	192.2(FWD)	9280	-14.0	323	0.005887

NOTES:
1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

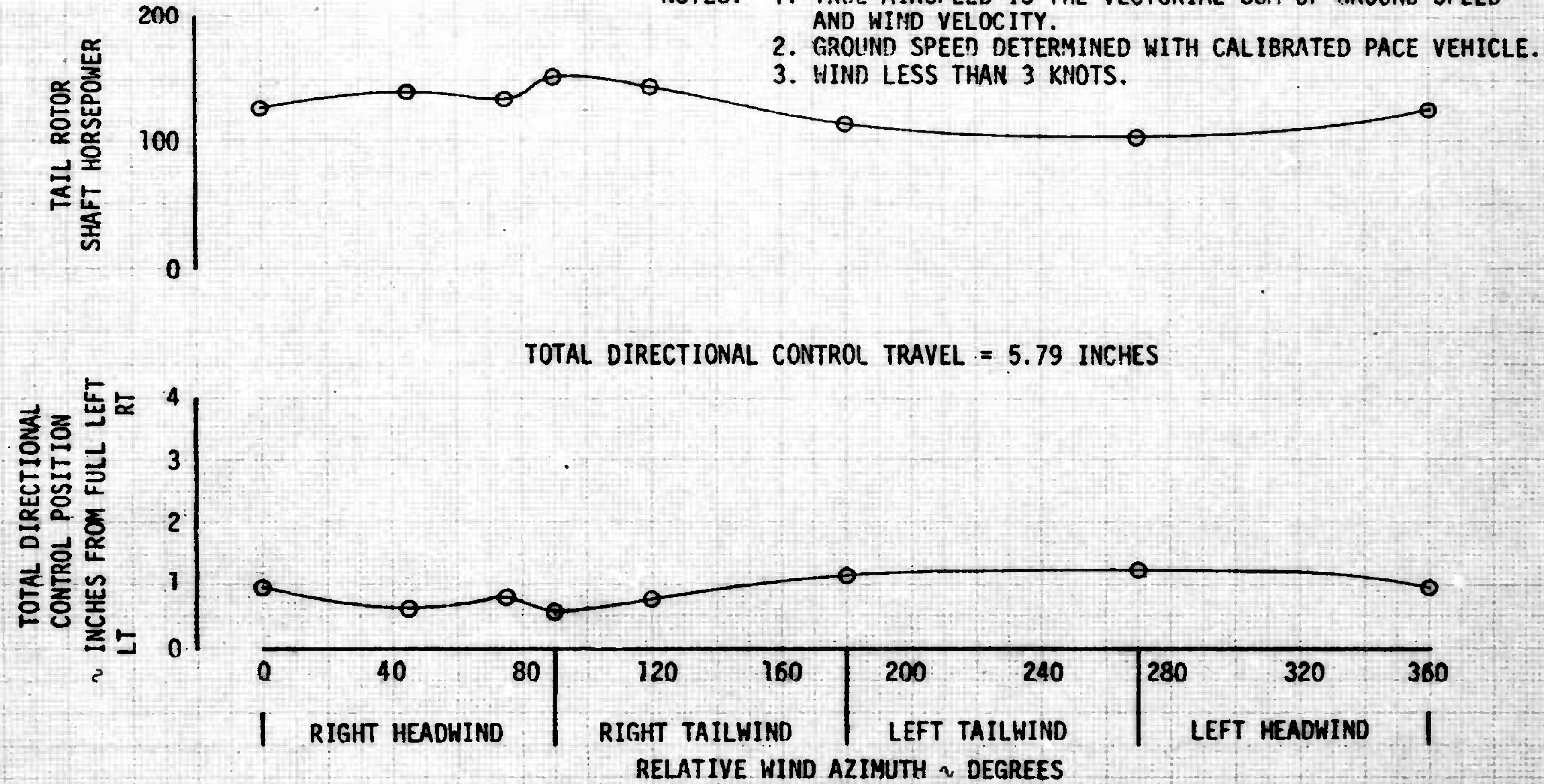


FIGURE 39

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
15	8920	192.2(FWD)	92[illegible]	-14.0	323	0.005900

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

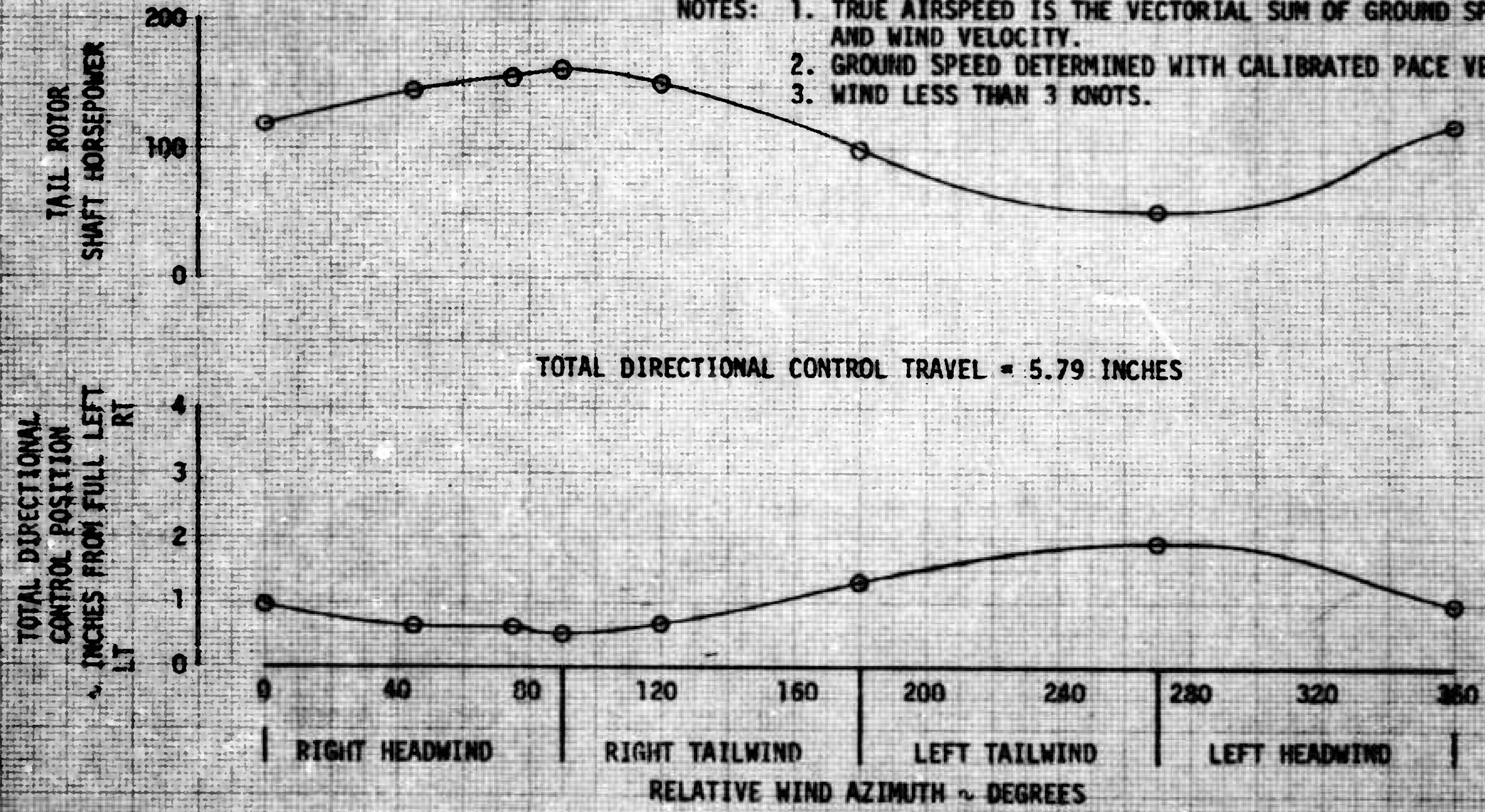


FIGURE 40
DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055
8 TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
20	8920	192.3(FWD)	9300	-14.0	323	0.005904

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

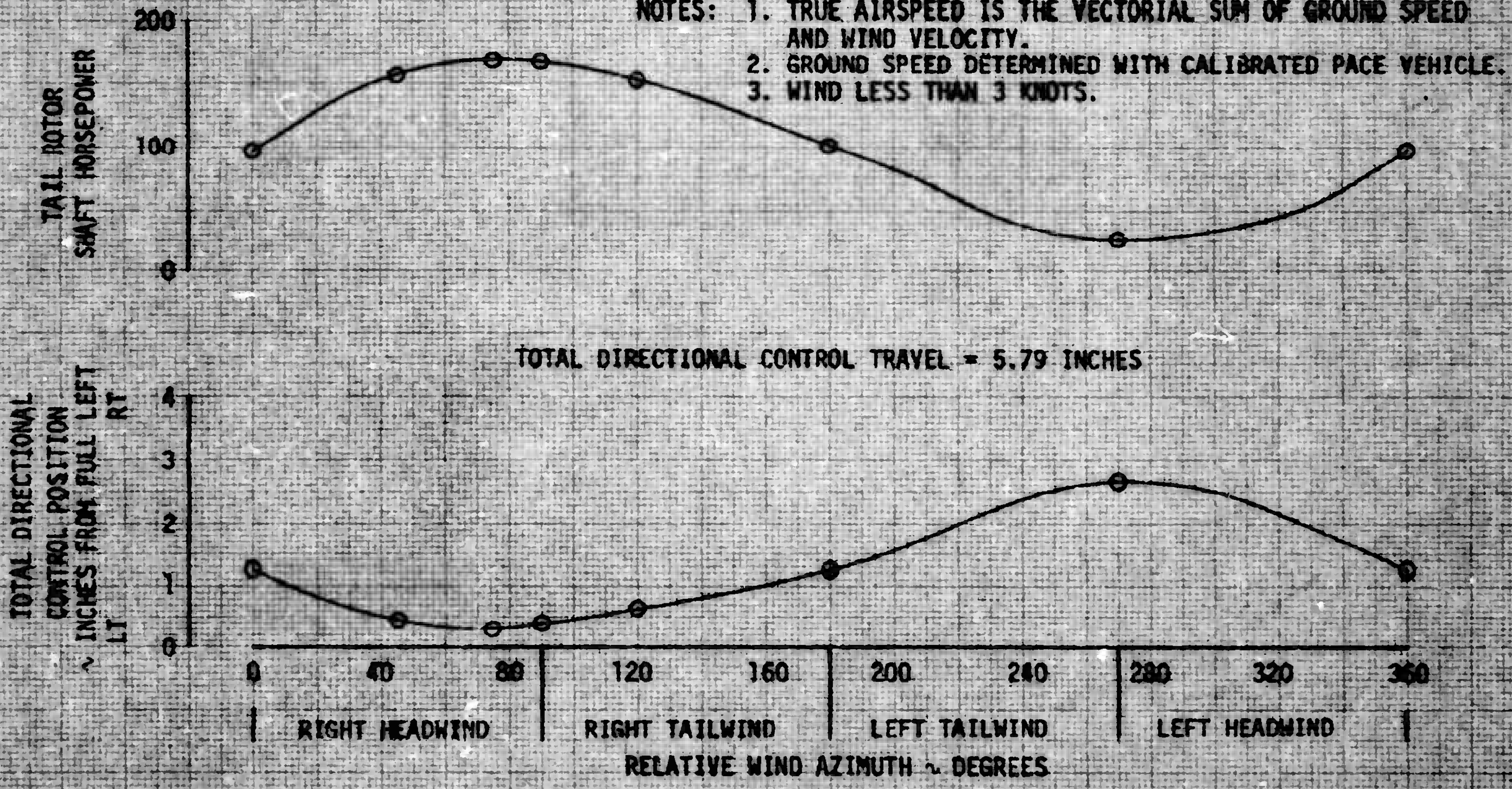


FIGURE 41

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
25	8920	192.2(FWD)	9320	-10.0	323	0.005908

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

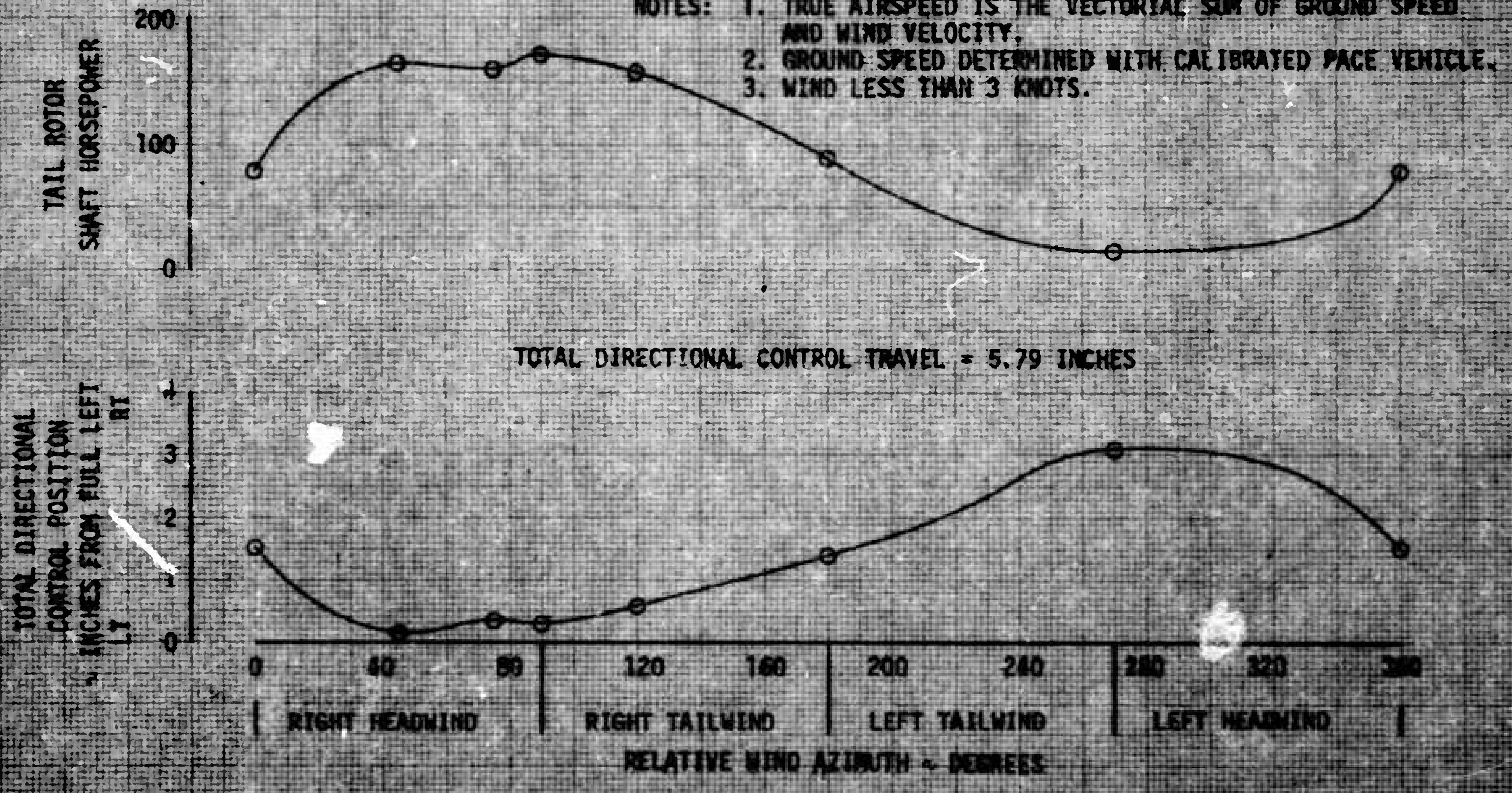


FIGURE 42

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
30	8900	192.2(FWD)	9420	-13.0	324	0.005876

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

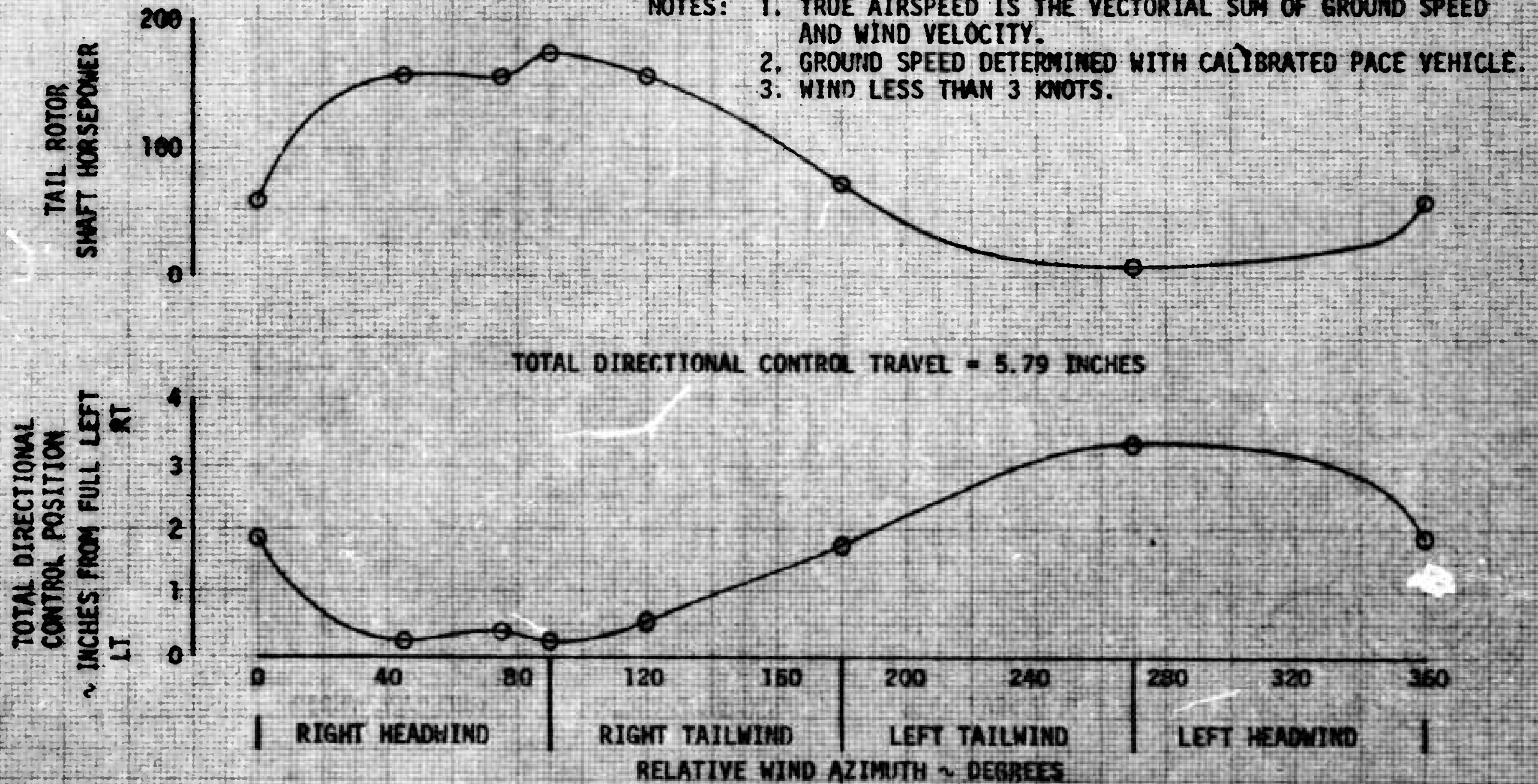


FIGURE 43

DIRECTIONAL CONTROL AT VARIOUS RELATIVE WIND AZIMUTHS

YAH-1S USA S/N 70-16055

8-TOW CONFIGURATION

AVG TRUE AIRSPEED ~KTS	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
35	8880	192.2(FWD)	9440	-11.0	325	0.005831

NOTES: 1. TRUE AIRSPEED IS THE VECTORIAL SUM OF GROUND SPEED AND WIND VELOCITY.
2. GROUND SPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
3. WIND LESS THAN 3 KNOTS.

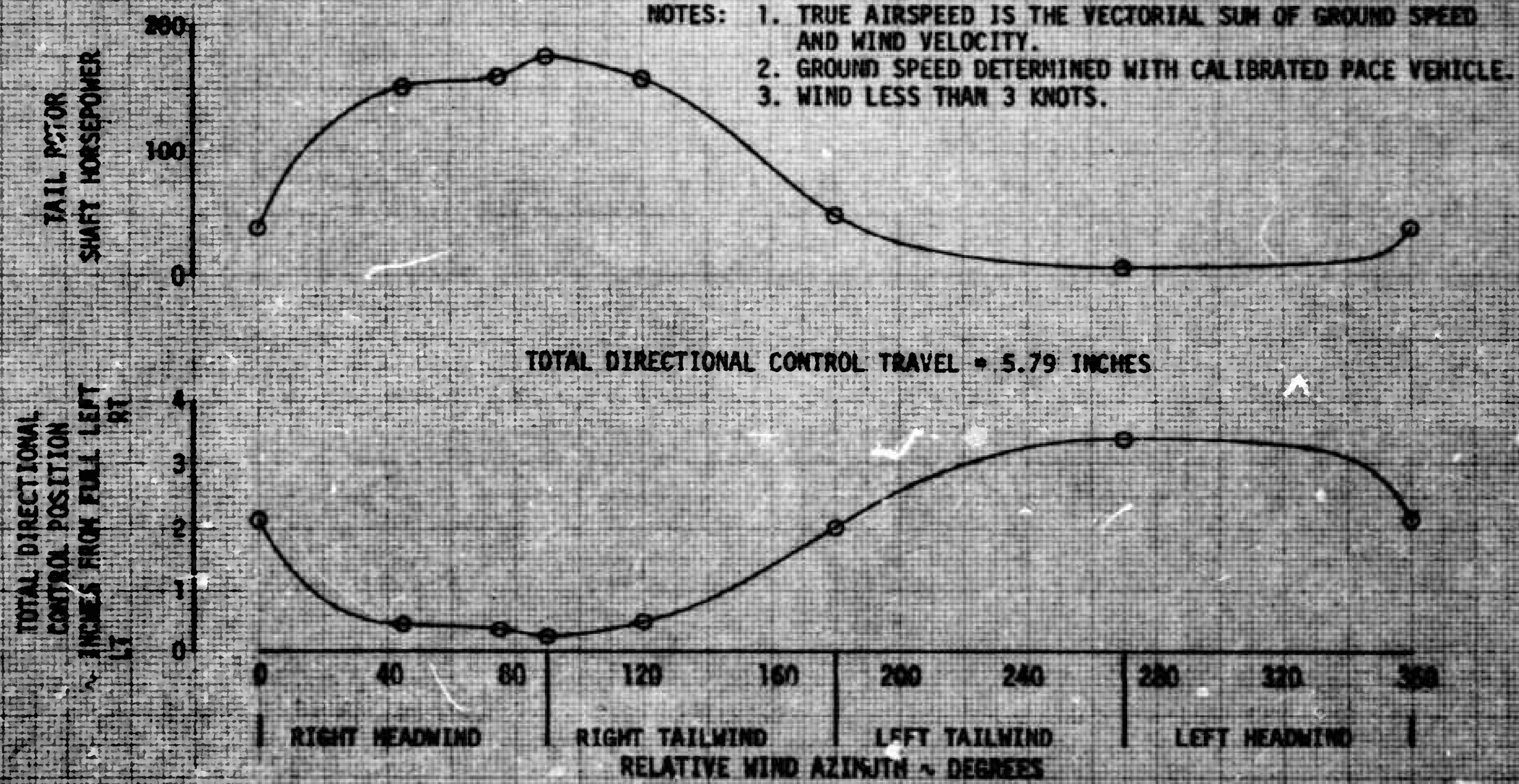


FIGURE 44
TRIMMED SIDEWARD AND REARWARD FLIGHT
YAH-1S USA S/N 70-16055
8-TOW CONFIGURATION

AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
[illegible]	192.6(FWD)	4280	8.0	324	[illegible]

NOTES: 1. TRUE AIRSPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
2. SKID HEIGHT = 15 FEET.

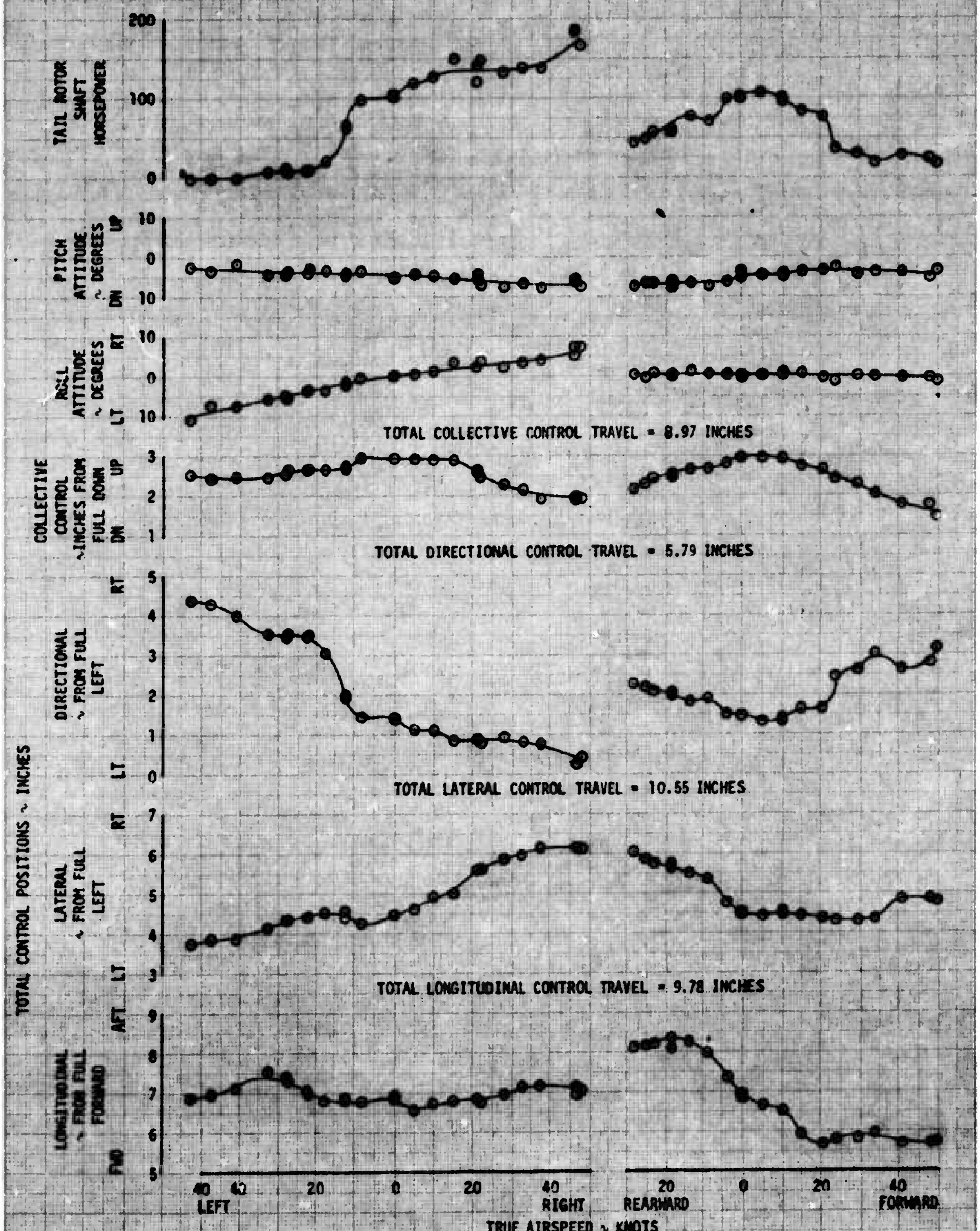


FIGURE 45
TRIMMED SIDEWARD AND REARWARD FLIGHT
YAH-1S USA S/N 70-16055
TOW CONFIGURATION

AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN.	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ °C	AVG ROTOR SPEED ~ RPM	AVG C_T
8940	192.2(FWD)	9600	-13.5	323	0.005937

NOTES: 1. TRUE AIRSPEED DETERMINED WITH CALIBRATED PACE VEHICLE.
2. SKID HEIGHT = 15 FEET.

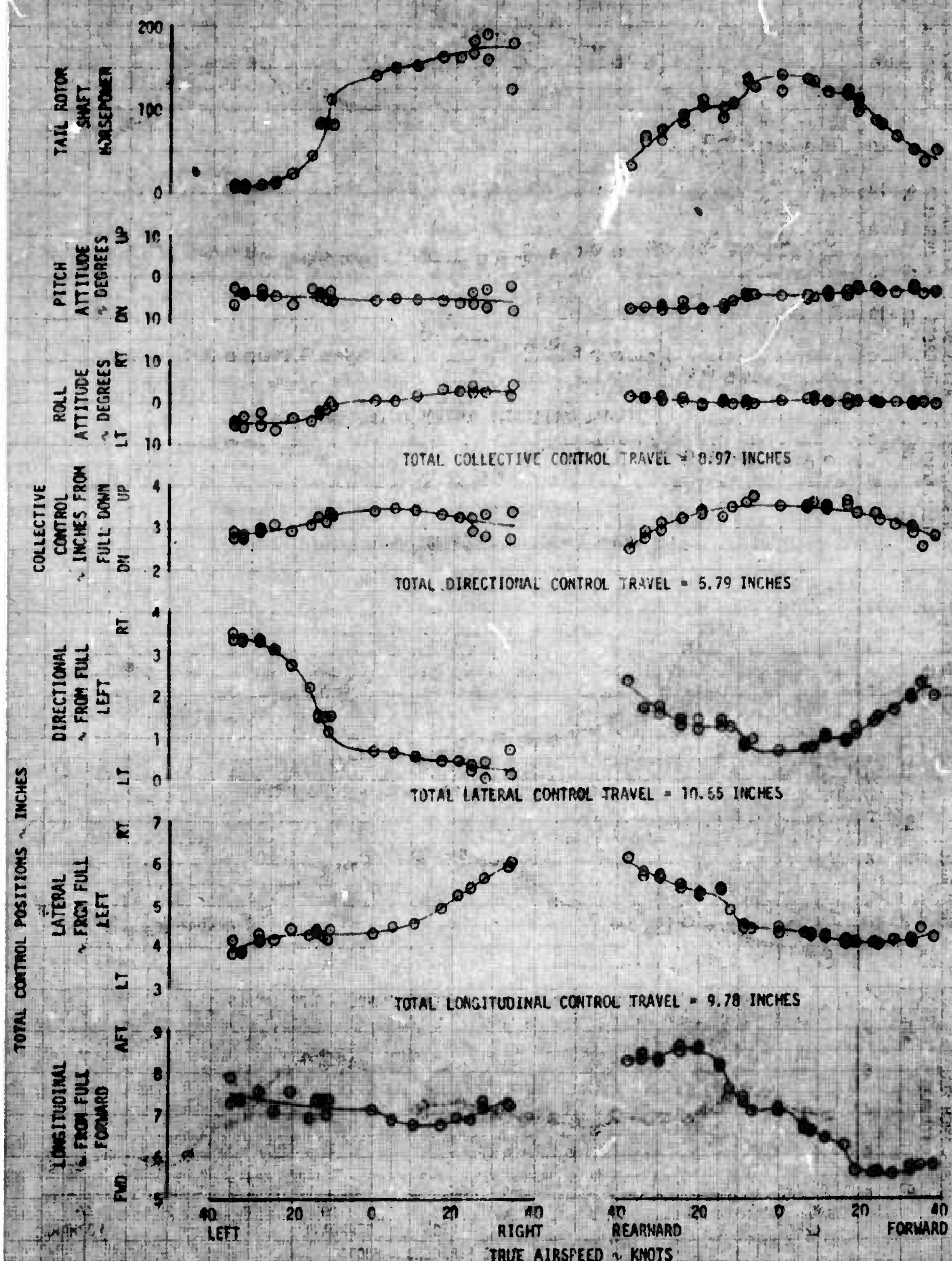


Table 1. Vibration Characteristics.[1]
Pilot Seat Vertical Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.016	.015	.058	.008	.065
Level flight at 10,000 pounds, V_H	.013	.025	.046	.115	.125
Longitudinal cyclic input, 1 inch	.013	.030	.018	.020	.031
Lateral cyclic input, 1 inch	.023	.048	.014	.038	.103
Directional pedal input, 1 inch	.020	.057	.030	.017	.080
Right sideward flight, 37 KTAS	.010	.034	.071	.050	.057

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.

Table 2. Vibration Characteristics.[1]
Pilot Seat Longitudinal Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.010	.025	.059	.005	.015
Level flight at 10,000 pounds, V_H	.008	.040	.044	.034	.037
Longitudinal cyclic input, 1 inch	.008	.025	.013	.004	.006
Lateral cyclic input, 1 inch	.013	.041	.015	.008	.015
Directional pedal input, 1 inch	.011	.046	.018	*	.012
Right sideward flight, 37 KTAS	.005	.049	.039	*	.013

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.
*Denotes small amplitude indistinguishable from noise.

Table 3. Vibration Characteristics.[1]
Pilot Seat Lateral Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.003	.014	.025	.010	.003
Level flight at 10,000 pounds, V_H	.003	.011	.012	.010	.034
Longitudinal cyclic input, 1 inch	.011	.009	.018	.012	.009
Lateral cyclic input, 1 inch	*	.019	.015	.015	.014
Directional pedal input, 1 inch	*	.019	.015	.014	.013
Right sideward flight, 37 KTAS	*	.024	.027	.003	.004

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.
*Denotes small amplitude indistinguishable from noise.

Table 4. Vibration Characteristics.[1]
Copilot Seat Vertical Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.006	.005	.008	.002	.036
Level flight at 10,000 pounds, V_H	.014	.061	.014	.052	.079
Longitudinal cyclic input, 1 inch	.006	.011	.006	.008	.025
Lateral cyclic input, 1 inch	.012	.044	.007	.019	.065
Directional pedal input, 1 inch	.011	.034	.008	.007	.049
Right sideward flight, 37 KTAS	.011	.045	.024	.024	.040

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.

Table 5. Vibration Characteristics.[1]
Copilot Seat Longitudinal Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	*	.008	.006	.002	.006
Level flight at 10,000 pounds, V_H	*	.017	.008	.015	.010
Longitudinal cyclic input, 1 inch	*	.003	*	.005	.002
Lateral cyclic input, 1 inch	*	.008	.003	.002	.004
Directional pedal input, 1 inch	*	.008	*	*	.006
Right sideward flight, 37 KTAS	.005	.018	.018	.009	.007

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.
*Denotes small amplitude indistinguishable from noise.

Table 6. Vibration Characteristics.[1]
Copilot Seat Lateral Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.005	.023	.020	.004	.010
Level flight at 10,000 pounds, V_H	*	*	*	.008	.013
Longitudinal cyclic input, 1 inch	*	*	*	*	*
Lateral cyclic input, 1 inch	*	*	*	*	*
Directional pedal input, 1 inch	*	*	*	*	.004
Right sideward flight, 37 KTAS	.005	*	*	*	*

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.
*Denotes small amplitude indistinguishable from noise.

Table 7. Vibration Characteristics.[1]
Instrument Panel Vertical Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.005	.012	.011	.044	.080
Level flight at 10,000 pounds, V_H	.013	.045	.074	.125	.124
Longitudinal cyclic input, 1 inch	.006	.008	.016	.064	.066
Lateral cyclic input, 1 inch	.010	.021	.008	.093	.124
Directional pedal input, 1 inch	.009	.018	.026	.058	.114
Right sideward flight, 37 KTAS	.009	.040	.056	.123	.059

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.

Table 8. Vibration Characteristics.[1]
Instrument Panel Longitudinal Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.004	.027	.040	.055	.069
Level flight at 10,000 pounds, V_H	.005	.070	.106	.068	.079
Longitudinal cyclic input, 1 inch	.011	.014	.015	.018	.018
Lateral cyclic input, 1 inch	.006	.050	.028	.024	.048
Directional pedal input, 1 inch	.006	.038	.032	.027	.044
Right sideward flight, 37 KTAS	.006	.045	.042	.063	.023

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.

Table 9. Vibration Characteristics.[1]
Instrument Panel Lateral Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.010	.038	.070	.064	.039
Level flight at 10,000 pounds, V_H	.004	.065	.052	.125	.077
Longitudinal cyclic input, 1 inch	.008	.020	.016	.053	.021
Lateral cyclic input, 1 inch	.010	.084	.021	.068	.040
Directional pedal input, 1 inch	.005	.059	.023	.059	.041
Right sideward flight, 37 KTAS	.008	.064	.049	.051	.025

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.

Table 10. Vibration Characteristics.[1]
Center-of-Gravity Vertical Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.008	.014	.013	.007	.028
Level flight at 10,000 pounds, V_H	.007	.037	.014	.068	.116
Longitudinal cyclic input, 1 inch	.010	*	*	*	.019
Lateral cyclic input, 1 inch	.009	.012	*	*	.050
Directional pedal input, 1 inch	.009	.010	.011	*	.051
Right sideward flight, 37 KTAS	.007	.018	.024	.012	.012

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.
*Denotes small amplitude indistinguishable from noise.

Table 11. Vibration Characteristics.[1]
Center-of-Gravity Longitudinal Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	*	.015	.014	*	.010
Level flight at 10,000 pounds, V_H	*	.032	.012	.020	.022
Longitudinal cyclic input, 1 inch	.015	.005	.007	*	.005
Lateral cyclic input, 1 inch	*	.013	.006	.007	.014
Directional pedal input, 1 inch	*	.015	.007	*	.015
Right sideward flight, 37 KTAS	*	.024	.013	*	.007

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.
*Denotes small amplitude indistinguishable from noise.

Table 12. Vibration Characteristics.[1]
Center-of-Gravity Lateral Acceleration

Flight Condition	Amplitude[2] (g)				
Frequency (Hz)[3] →	5.4	10.8	21.6	32.4	43.2
OGE hover, maximum power[4]	.006	.009	.035	.008	.021
Level flight at 10,000 pounds, V_H	.005	.056	.026	.024	.060
Longitudinal cyclic input, 1 inch	.016	*	.018	*	.009
Lateral cyclic input, 1 inch	*	.030	.012	*	.023
Directional pedal input, 1 inch	.007	.014	.015	.007	.023
Right sideward flight, 37 KTAS	.011	.020	.024	*	.007

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Single-amplitude peak.
[3]Frequencies presented denote rotor harmonics of 1/rev, 2/rev, 4/rev, 6/rev, and 8/rev.
[4]Density altitude: 1200 feet.
*Denotes small amplitude indistinguishable from noise.

Table 13. Pitch Link Loads.[1]
Main Rotor

Flight Condition	Force (lb)	
	Mean[2]	Oscillatory
OGE hover, maximum power[3]	+400	±500
Level flight at 10,000 pounds, V_H	Zero	±750
Longitudinal cyclic input, 1 inch	+1100	±650
Lateral cyclic input, 1 inch	+1000	±650
Directional pedal input, 1 inch	+900	±650
Right sideward flight, 37 KTAS	+800	±600
Rearward flight, 36 KTAS	+800	±600

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Positive sign convention denotes tension.
[3]Density altitude: 1200 feet.

Table 14. Pitch Link Loads.[1]
Tail Rotor

Flight Condition	Force (lb)	
	Mean[2]	Oscillatory
OGE hover, maximum power[3]	-175	±50
Level flight at 10,000 pounds, V_H	-25	±50
Longitudinal cyclic input, 1 inch	-250	±75
Lateral cyclic input, 1 inch	-275	±75
Directional pedal input, 1 inch	-375	±100
Right sideward flight, 37 KTAS	-375	±50
Rearward flight, 36 KTAS	-150	±50

[1]Longitudinal cg: 192.3 inches (forward).
Rotor speed: 324 rpm.
SCAS ON.
Density altitude: 9600 feet.
8-TOW configuration.
[2]Negative sign convention denotes compression.
[3]Density altitude: 1200 feet.

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